The Measurement of the Aarberg Base Line in Switzerland, and the Apparatus of General Ibaner.*

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The association of all the European governments, called the *Europaeische Gradmessung*, or Geodetic Society, and formed for the purpose of determining the most probable shape of the earth, was founded in the year 1861, principally through the agency of the then Prussian general, Baeyer, who, as a young officer, assisted Bessel in measuring his celebrated base-line in Eastern Prussia. The duties of this association are as follows: Most accurate triangulation; astronomical determination of the triangulation points to determine their geographical co-ordinates; observations of the pendulum; finally the establishment of an extensive set of monuments, the elevations of which are carefully determined.

Switzerland was one of the first to adopt General Baeyer's scheme. Most of the work there has been finished. The beautiful map of Switzerland, made under the direction of General Dufour, is based upon a base-line 13 kilometres (8.1 miles) long, measured in 1843 in the Canton Bern. The great improvement of the apparatus, instruments and methods of handling them made during the last 50 years has made it desirable to have a new base measured, so as to bring the Swiss geodetic work into harmony with that of other states.

The joint commission, appointed by all the different governments, has declared, that in their opinion the apparatus, devised by the Spanish general Ibañer and made by Brunner in Paris, is the best base-measuring apparatus. They ordered a second one, exactly like the original, which is used by each state for their work, so that a complete uniformity of the different sections will be obtained.

The triangulation of Switzerland will be the one on which that of Germany, Italy, France and Austria will close, on account of the central location of the first named country. In order to have a perfect check on the whole work, it was decided to measure three base-lines, one at each corner of the Swiss triangulation. The Spanish Government offered to loan their new and improved apparatus, and General Ibañer volunteered to instruct in person and with his own corps of assistants, the Swiss engineers, by measuring one of the three bases himself.

The following is a description of the apparatus and its operation:

In October 1853, the Spanish Government decided to prepare and construct a new map of the whole State. A commission of officers of the general staff, the artillery, and the engineers, was appointed to make the necessary surveys. This commission thought it their first duty to measure a base-line and to devise and construct a new and accurate apparatus to do it with. The then colonels Ibañer and Saavedra, were charged with the investigation of this question, and soon proposed an apparatus, which was adopted by the commission. Both the officers were sent to Paris to supervise its construction at Brunner's. They were assisted in this and in the determination of the constants, and in the comparison with the standard metre of the Paris Observatory, by the physicists Regnault and Wertheim, several prominent geodetic officers and by the astronomers Leverrier and Villarceau.

The first base-line, measured with the new apparatus in Spain, was 15 kilometres (9.35 miles) long. It was divided into five nearly equal sections, which were connected with a set of triangles, so that each of the five sections as well as the whole base could be calculated by means of these triangles. As early as the beginning of this century the astronomer Schwerd had expressed the opinion, that a base-line of a length of only a few kilometres would be sufficient to determine the sides of triangles of the first order. To prove this, he measured in 1820 a line only 850 m. long, and computed therefrom the 15 kilometres long "great base-line of Speyr" within 0.1 m. At the above mentioned Spanish base-line four sections and the whole line itself were computed from the middle section, 3 kilometres long, by triangles, and the following differences, when compared with the direct measurement, were found:

Sec. 1, 3 m. m.; Sec. 2, 2 m. m.; Sec. 4, 3 m. m.; Sec. 5, 2 m. m.; and the total base, 4 m. m. This proves that a base of 3 to 4 kilom. will be sufficient for nearly any case. The measurement of the first Spanish base lasted from May 22, to September 7, 1858, requiring 78 actual working days, which is equal to 5.2 days per kilom. Since then the apparatus has been greatly simplified by Gen. Ibañer, so that the measurement of one kilometer can be done in one day now. The principle of this new apparatus is the same as that of the first one, which is nothing else than that which Hassler has already employed in the coast survey of the United States. The details of the apparatus, however, as well as its operation have been greatly improved.

An iron rod, 4 m. (13.12 ft.) long, is divided into half metres. Two microscopes are set up independently of the supports of the rod, alongside of the same, and over these divisions, usually over the zero, and over the 4th meter point. After the microscopes have been accurately set, the rod is moved its full length, the hind-end being set exactly under the first microscope while the second microscope is moved ahead and set up over the other end of the rod. Then the same operation is repeated. In this way is measured each time the distance between the two microscopes, exactly equal to one length of the rod.

FIG. 1.

The measuring rod or bar is made of wrought "T" iron, and weighs about 50 kilog (110lbs.) near the two ends, and at each half meter, small plates of platinum are fastened, upon which the exact measure is engraved. On the back are 4 thermometers (1, 2, 3 & 4, in Fig. 1) The bulk containing the mercury is directly connected with the rod and is embedded completely in iron-filings, the scale is graduated to a fifth of a degree; and they are covered with a glass plate, which is held by a slip of brass. In the centre of the rod a level

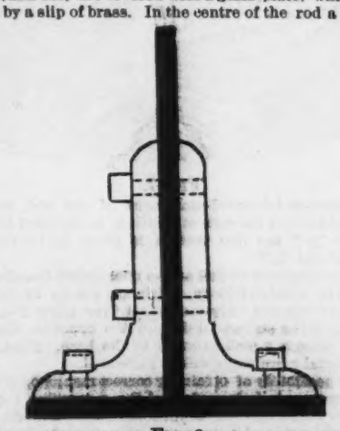

FIG. 2.

is set up. (Fig. 3.) Its graduation admits of a reading to 10". The rod is never laid exactly horizontal, but its inclination is read on the graduation, and later corrected in the calculation, which saves a great deal of time. At about 1m. from each end are handles screwed on to the rod by means of which the latter is carried by two men; 13 angle irons screwed upon the rod at equal distances serve to stiffen the same.

The co-efficient of expansion of the rod, the true length between the graduation-lines, the thermometers etc., are carefully compared with the Paris standard. With such a rod, 4m. long the base-line or rather a line exactly parallel thereto, is measured.

The second part of the apparatus is an instrument similar to a theodolite, the telescope of which can be turned vertically downward, and to one standard of which is attached an arm, of about 20cm.(7.87 in.) length bearing a small microscope. The cross wire of the microscope is in exactly the same vertical plane with the horizontal axis of the telescope; therefore it forms a right angle with the line of sight. The tripod of this instrument has a hole through its centre. If the telescope is now set up, exactly perpendicular over the point of beginning of the base line, and then turned horizontally and pointed along the base-line the iron wire of the microscope will be in a plane at right angles to the base line and laid through its beginning. Now suppose, that a second theodolite of the same construction be set over the end of the base-line, and the same operation be performed; then the cross-wire of this microscope is also in a plane at 90° to the base and laid through the end of it. Then, the distance between the cross-wires of the two microscopes would be exactly equal to the length of the base-line itself.

It is furthermore evident that, if the base is divided into several sections, and the same operation be performed at the end of each section, the parallel line established by the microscopes, will also be divided into the same number of sections as the base itself. If the supports of the apparatus allow a movement of the rod lengthwise in addition to the above, then any desired distance from the beginning of the rod, may be measured by the microscope. Figs. 4 and 5 will serve to explain the above.

In Fig. 4 the tripod is set so that the central opening is over the point of beginning. This, as well as the end of the base, is marked by a well set stone block with a small brass cylinder set into it; the exact point is marked by a cross on top of the brass cylinder. The first operation is to bring the telescope of the microscope-theodolite (the name of this instrument) exactly vertical over the point of beginning. The axis of the telescope is set horizontal by means of the eccentric level, Fig. 4 a, which is set upon the axis and balanced by two counter weights. The levelling-up is done in

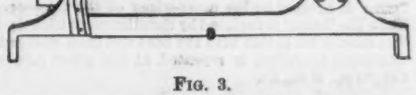

FIG. 3.

the usual way by the three levelling screws. As soon the line of sight of the telescope is brought to a coincidence with the vertical axis of the instrument, then it must be vertical itself. This can be checked by seeing whether the cross-wires always cover the same point, when the instrument is turned around its vertical axis. Any adjustment can be made by the screws "h" and "v."

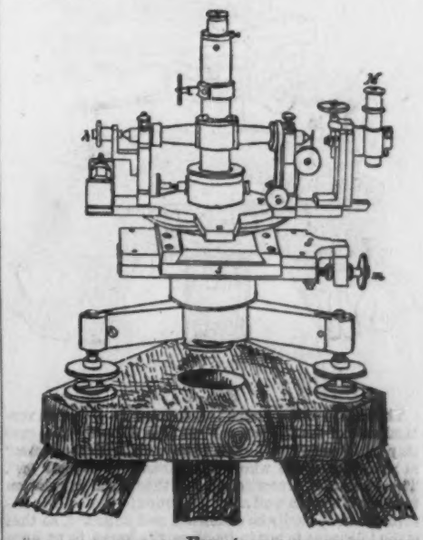

FIG. 4.

The whole upper part of the theodolite can be moved by the two screws "m m" (one cannot be seen in the figures) and the slides "s s" in two directions, at right angle to each other. After the telescope has been set vertical it is centered exactly by means of the slides "s s." If the instrument is then turned around its vertical axis the cross-wires must cover the point of beginning in all positions.

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One of the standards of the telescope has an extension, bearing the microscope M. It has two parallel hairs, between which the line of graduation of the rod is taken. The microscope follows every turn of the instrument around its vertical axis.

An axis of steel, exactly similar to the axis of the telescope, but which has, instead of the telescope, a so-called "mira," formed by two fine, dark cross-lines, is also used (shown in Fig. 6.) This axis is laid into the standard of the microscope-theodolite (Fig. 6) and serves now to line in the apparatus in the base line. The proceeding is as follows:

At the announcement of the measurement the tele-

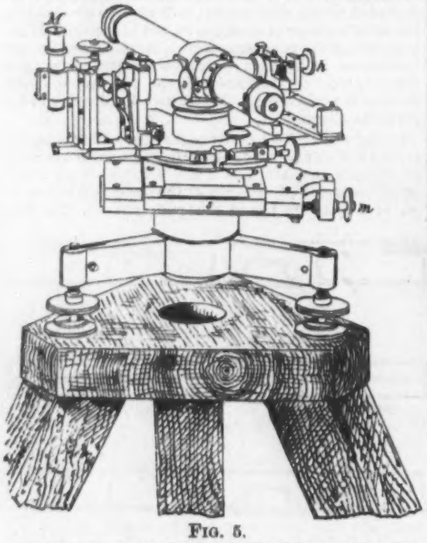

FIG. 5.

scope is set vertical over the point of beginning. (Fig. 4.) Then it is replaced by the telescope for alignment (Fig. 5), which is set in line with the base and then clamped. Nearly 4 in. from the first microscope-theodolite, there is another one set up in the base-line, which is like the first one with the exception of having the "mira" instead of the telescope. The observer at the first microscope-theodolite takes a sight to this "mira," and an assistant moves the entire upper part of the apparatus at right angle to the base-line, by means of the screw "m" and slide "s," until the centre of the "mira" is covered by the cross-wires of the telescope. Then the "mira" is replaced by the alignment telescope, this exactly set in line with the base and then clamped. The same operation is repeated at the other points, 8 m., 12 m,, 16 m., &c.

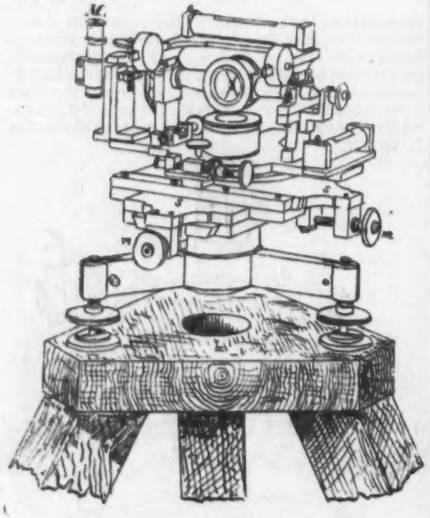

FIG. 6.

The centre of the "mira" must coincide with the vertical axis of the instrument. If this is really the case its position will not change, if the axis, with the "mira" is reversed or the whole instrument is turned 180°. Therefore the correct position of the "mira" in relation to its own axis as well as in reference to that of the instrument can easily be examined and adjusted, so that if the telescope is put in its place, the same is at once centered. To see whether the wires of the microscope are in the vertical plane laid through the axis of the telescope, the position of the microscope and of the vertical axis, i. e. the centre of the instrument, are marked on a firm support. Then the instrument is turned 180° by pointing the alignment telescope, which was previously set in one direction, in the opposite direction. The new position of the microscope is marked again on the support. Then the three points must be in a straight line, square to the base line.

The correct position of the microscope is marked once forever by the maker.

The following is a summary of the operations described. The first microscope-theodolite is set over the point of beginning of the base-line, then the second microscope-theodolite—with a "mira"—is set up a distance of nearly 4 m., about in line, then it is lined in by sighting from the first instrument, then the

FIG. 4A.

"mira" is replaced by an alignment telescope, and from this point another microscope-theodolite at about 8 m. distant from point of beginning is lined in, and the operation is repeated. In this way the microscopes are fixed at points exactly corresponding to the points of the base itself and in an exactly parallel line to it.

It is necessary that the maker should fix the microscopes of the different instruments at exactly the same distance from the centre of the instrument. The supports of the measuring rod consist of metal tripods, which allow movements in all three directions. (Fig. 7.) Two slides "s s," with the screws "m, m" permit a movement of the direct support "l" square to and in the same directions as the base-line. The centre of the tripod is hollow; a pivot with screw goes through it, to which the upper plate of the support is fastened. By turning the screw "k" the slide with the rod can be raised or lowered. The roller "r" serves to facilitate

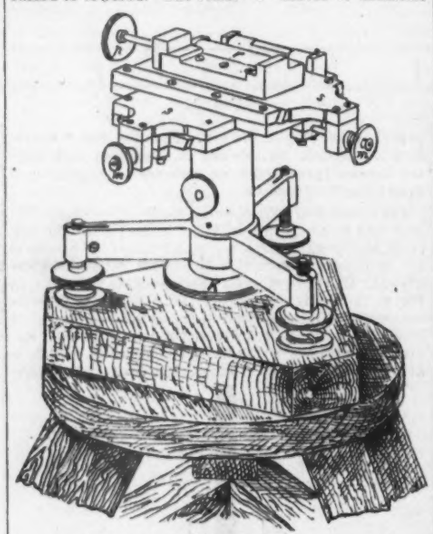

FIG. 7.

the back-and-forward-movement of the rod, which, when in nearly the correct position, is clamped by the screw "p;" the fine motion is given by the screws "m m" and "k."

These supports as well as the microscope-theodolites stand on wooden tripods, which are set up in such a manner that the only movement they allow (that by means of the screws "d d" and the opposite hinges) takes place in a plane square to the base. Thus, any accidental movements will be prevented.

The possibility of obtaining correct results by means of microscopes, independent of the measuring rod, is mainly based upon the condition, that the tripods, carrying the rods and instruments, remain perfectly intact and unchanged during the time of observation. They will do this the more certainly, the firmer the supports and the shorter the time of observation. Gen. Ibaner, therefore, measures only upon perfectly solid ground, and reduces the time of the measurement to a very few minutes. At the Aarberg base the tripods were set upon the macadamized country road; their stability was perfect.

The tripods are so arranged that those for the microscope-theodolites, which are 0.20 in. (7⅞ in.) higher than the others, stand at both ends, and the tripods for the rod at about ¼ and ¾ of the length of the rod. The measurement is done under portable tents. Fig. 11 shows the entire arrangement during the measurement. Simultaneously there are used four microscope-theodolites, four metal tripods for the rods, six large wooden tripods for the microscope-theodolites, ten small wooden tripods for the brass tripods of the rods, and two wooden measuring rods, each 4 m. long. Two observers with several assistants put all the wooden tripods in line by means of these wooden rods and raise them to their proper elevation. Two more observers with their assistants follow and line them in accurately.

At the measuring rod itself there are four observers, two on each side; the first two set the beginning and end of the rod in coincidence with the cross-wires of the microscopes, the two others observe the four thermometers and the level. Each one of them makes all the 5 observations and then compares them with more of the others. With the observations all finished, at a

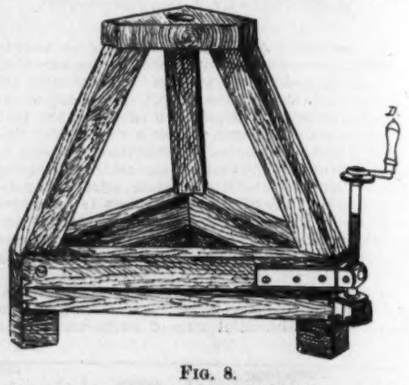

FIG. 8.

given order two assistants take hold of the rod at the handles and carry it up on the tripod, already set in plan ahead. At the same time, the other microscope theodolites are set up in these positions; the rod is laid approximately in its correct place and the observations can proceed at once. The instruments and tripod used at the first rod, and the tents of the finished section are then taken up, carried ahead, re-erected, etc. Each observer and every assistant has a certain part assigned him and nothing else to perform, which is repeated for each new position of the rod.

The work is so arranged, that ample time is allowed, and that it can be carried out without disturbing any of the other observers and assistants.

After 100 lengths or nearly 400 m. have been measured, a short halt is made and a monument is established in the first measurement, its exact position being determined in the second measurement.

The monuments are stone-blocks with a brass plate, 10—15 mm. (0. 4 to 0. 6 in.) square cemented into it.

Then the tripod of the microscope-theodolite is set over it the same as at the beginning of the base (Fig. 4.) A metal ring, having a small hole in its centre (Fig. 12) is moved upon the brass plate until the hole coincides with the cross-wires of the microscope, the finer movements being made by the screws "R. R."

Then the steel-pin "St" is set into the cylinder "H", carefully pressed down and the brass plate below is marked.

In Fig. 12 the pin is shown to be already inserted in

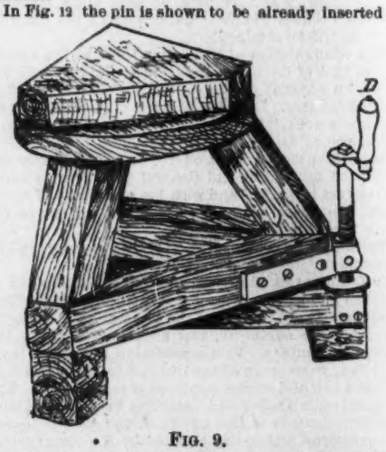

FIG. 9.

the cylinder "H"; during the entering of the small hole the pin must be taken out so that the observer of the telescope can look through the cylinder. The pin "St" fits very accurately, and the whole apparatus is so well made, that, if the same is taken away, the mark made by the pin upon the brass plate appears exactly in the centre of the telescope. As the cross-wire of the microscope, which was put over the end-line of the rod, is in a plane, which is square to the base and laid through the vertical telescope, the monuments and the end-line of the rod are in the same vertical plane, or in other words, the piece measured by the microscopes along a parallel line will be exactly as long as the section of the base fixed by the monuments.

The point marked on the brass plate is very fine. In order to find it in the future, with ease and certainty, some heavier lines are marked by hand around it. Then the monument is covered with a box and secured against any mischievous interference.

As mentioned above, the rod is divided in half metres. At the end of the base the distance will very likely not correspond to one of these graduations. It is therefore necessary to measure the rest separately. A small scale (Fig. 13) is used for this, which is screwed on the rod. It

is divided for its entire length into millimetres and the last millimetre into tenths. After the vertical telescope (Fig. 4-5) is exactly set over the end of the base, the scale is so fixed under the wires of the microscope, that the half-metre line of the rod, nearest the microscope lies between the two first graduation lines of the scale. As this is divided into tenths of a millimetre, the hundredths can be estimated with a magnifying glass. The scale is 30 cm. long (11.8 in.).

The second measurement of the base is done just in the same way as the first one.

It may be mentioned that the base-line is marked out by three "miras," as shown in Fig. 14. After the iron-rod is set vertical by means of a level, which can be fixed to it at any point, it is exactly lined in, and its position marked by a point on a small brass plate placed on the ground. During the measurement two "miras" must always be visible from each stand-point, on account of which a "mira" must be set beyond the end of the base in its prolongation. After the measurement has progressed to any one "mira," it is taken out of line and set aside. As the mark upon the plate on the ground remains, it can easily be replaced for the next measurement.

As soon as 50 lengths of the rod, or nearly 200 m. (656 ft.) have been measured, the field notes are sent to the computors—a corps made up of one chief and four assistants—who work in some near house or in a tent. All the reductions are so simple, that the computation always keeps up with the measurement, so that immediately after the second measurement has been finished the final result is known. This affords the great advantage of being able to repeat the work in case any error should have occurred.

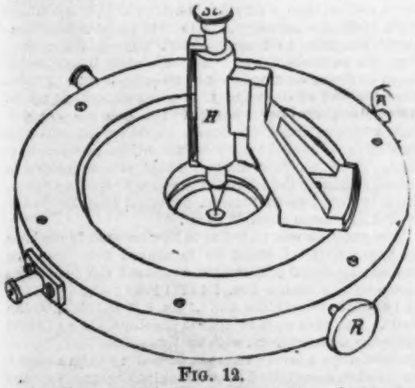

FIG. 12.

If we call:

Ftn = the length of the rod, ascertained by observation at a temperature of tn.

E = coefficient of expansion of the iron rod.

c = ½ sin.° J. Ftn = correction on account of the inclination of "J" of the rod, read at the graduation of the level.

t = temperature during the measurement; we have the true horizontal length of one length of rod: then

p = Ftn − (tn − t) E − c and after "n" lengths of rod, the true measured length.

D = n Ftn − (ntn − [t]) E − [c].

The values of "c" are arranged in tables for every 10″. As the inclinations can be read to 10″ in the graduation of the level, the values of "c" can be taken directly from the tables without any interpolation. "n" is generally equal to 100, as a monument is set at every 400 m. (13.12 ft.) Ftn, tn and E are constants.

The whole calculation therefore is nothing more than the looking up and the addition of the values of "c", the calculation of the averages of the temperatures and their addition, and the multiplication with E. As a check the calculation is made in duplicate at once.

On August 17th, 1880, Colonel Casado with 12 officers and 10 assistants of the geographical and statistical bureau of Spain arrived at Aarberg. The day following the instruments were unpacked, cleaned and adjusted, the tents put together and erected, the monuments for the beginning and end of the base-line established, the base-line staked off and marked by three "miras" at 900, 1800 and 2600 m. from the beginning. On the 20th General Ibañez arrived. When he made a reconnoissance in the month of June previous, he had expressed the wish, that the base should be 2400 m. (7873 ft.) long, as he referred dividing his base-lines into sections of 400 m. each. This length would also be sufficient to determine the 30 kilometres (18.6 miles) side of the adjacent triangles of the first order. The first measurement of the base was finished in three days and monuments set at every 400 m. Although the weather was very unfavorable, the second measurement was also finished in three days. The time in which the different sections were measured, was as follows:

Sec.	First Measurement.	Second Measurement.
1	167 minutes	126 minutes
2	164 "	119 "
3	147 "	144 "
4	146 "	128 "
5	141 "	151 "
6	169 "	169 "
	Mean 156 "	Mean 140 "

FIG. 11.

The second measurement is always more rapid, as no monuments have to be set.

The results of two measurements were as follows:

Sec.	I.	II.	I—II.
1	400.0336	400.0326	+ 0.0010
2	400.0351	400.0329	+ 0.0022
3	400.0349	400.0350	− 0.0001
4	400.0514	400.0519	− 0.0005
5	400.0322	400.0326	− 0.0004
6	399.9001	399.9002	− 0.0001
	Base 2400.0873	2400.0852	+ 0.0021

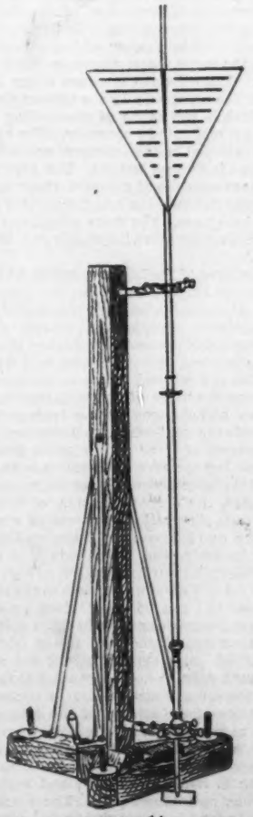

FIG. 14.

The greatest inclination of the rod during the first measurement was 1°50′, the correction for the inclination is on an average 1 cm. (0.393 in.) per section.

The first day was exceedingly unfavorable for measurement, especially during the work on the second section, as the pouring rain wetted the tents through and through. The difference is the greatest in this section.

The average errors are, for the double measurement of one section, m = ± 0.5 mm. (0.019 in.). Double measurement of one base, m = ± 1.2 mm. (0.047 in.).

The constants of the apparatus are determined by General Ibañez as follows: length of rod at a temperature of 21.935C° Ftn. = 4.0006542 ± 0.000001 m. Coefficient of expansion: e = 0.043193 + 0.000009 m. The average error of the base is not appreciably affected by the uncertainty of the constants. We have to take into consideration only the mean errors.

The reason for inviting Gen. Ibañez, with his corps, to measure the Aarberg base, was principally for the instruction of the Swiss officers, (eight officers and ten sergeants of the Engineers under the direction of Col Dumur and Prof. Hirnt,) who were detailed to measure the other two bases in Switzerland. None of the commissioned officers had had previous experience in the use of such apparatus. In spite of this they were able, after a few instructions, to measure 800 m. (2624 ft.) a day, which speaks well for the simplicity of the apparatus. Gen. Ibañez's claim, that he would measure 800 m. (2624 ft.) in the forenoon of every day, and so finish the double measurement entirely in six days, was received with much doubt before the beginning of the work. But the sceptics were soon convinced, when the General measured the first 800 m. (2624 ft.) in five hours.

In the afternoon of the 27th, the Swiss made their first attempts. On the following morning General Ibañez gave to each Swiss observer one of his officers, who had performed the same duty at the Spanish measurement. After about 30 lengths were measured all the Spaniards were withdrawn, and the Swiss proceeded alone. To their great satisfaction they closed at the first monument with a difference of 0.6 mm. (0.236 in.). The time occupied for each section by the Swiss was as follows:

Sect. 1.	300 minutes.	Sect. 4.	205 minutes.
2.	226 "	5.	189 "
3.	208 "	6.	218 "

which shows, that the duration of one measurement decreased in each successive section, with the exception of the last when the measurement of the monument required more time. The results of the measurements were as follows:

Sect.	Swiss meas.	Mean of Spanish meas.	Difference.
1	400.0337	400.0331	+ 0.0006
2	400.0324	400.0340	− 0.0016
3	400.0353	400.0349	+ 0.0004
4	400.0519	400.0517	+ 0.0002
5	400.0319	400.0324	− 0.0005
6	399.8940	399.9002	− 0.0062
	Base 2400.0832	2400.0833	− 0.0001

FIG. 13.

If we accept, that all three measurements are of equal weight, we have the following values for each section:

Sect.	Result.	Mean.	Difference.
1	400.0336		+ 0.3 mm.
	.0326	400.0333	− 0.7
	.0337		+ 0.4
2	400.0351		+ 1.6
	.0329	400.0335	− 0.6
	.0324		− 1.1
3	400.0349		− 0.3
	.0350	400.0351	− 0.1
	.0353		+ 0.2
4	400.0514		− 0.3
	.0519	400.0517	+ 0.2
	.0519		+ 0.2
5	400.0322		+ 0.0
	.0326	400.0322	+ 0.4
	.0319		− 0.4
6	399.9001		+ 0.7
	.9002	399.8994	+ 0.8
	.8980		− 1.4

The mean errors are for the three measurements: for one section m, = ± 0.5 mm. (0.0196 inches); for the whole base m = ± 1.2 mm. (0.0471 inches).

The third measurement, therefore, did neither decrease nor increase the final result.

The coefficient of expansion of iron is nearly $\frac{1}{80000}$. One degree (centigrade) expands the rod 0.043 mm. This makes for the entire length of the base about 25 mm.

One tenth of a degree change in the accepted mean temperature alters the length of the base by 26 mm., which shows with how great a care the temperatures should be observed. The four thermometers are of exact calibre and the correction of their zero-points is made for each base. The mean temperatures (centigrade) during the measurements were:

Sect.	I.	II.	III.
1	16.5°	17.7°	16.4°
2	18.0°	22.0	22.3
3	16.6	16.3	17.0
4	22.5	23.8	24.7
5	15.6	15.5	16.4
6	19.3	18.9	24.0

If we calculate the differences of these temperatures and set opposite to them the differences of the measurements, we have:

Sect.	I—II.		I—III.		II—III.	
	Δt	ΔM	Δt	ΔM	Δt	ΔM
1	−1.2°	+1.2mm.	+0.1°	−0.1mm.	+1.3°	−1.1mm
2	−4.0°	+2.2	−4.3	+2.7	−0.3	+0.5
3	+0.3	−0.1	−0.4	−0.4	−0.7	−0.3
4	−1.3	−0.5	−2.2	−0.5	−0.9	+0.0
5	+0.1	−0.4	−0.8	+0.3	−0.9	+0.7
6	+0.4	−0.1	−4.7	+2.1	−5.1	+2.2

By this, we see, that the mean temperatures, at which the sections were measured, differ by 4 to 5°. Where the differences in temperatures are largest—in sections 2 and 6—the differences in measurements are also the largest, and for the highest temperatures we have the shortest measures. From this we would conclude, that at a rapid increase of temperature, as for instance in the third measurement of section 6, from 21 to 28°, the thermometers respond slower to this increase than the rod itself, and that therefore the correction used for the indicated temperature was too small. As the rod is in direct contact with the atmosphere, but the thermometer is separated from it by a glass cover, it may be possible—although hardly probable—that the latter is not influenced by changes of temperature as rapidly as the former. It may be further said, as the measurements were only made during the forenoon, that the temperature very likely was constantly increasing, and therefore would have influenced the measurements all in one and the same sense. In reality, however, the third measurement was made partly during the afternoons; and then, during the first two measurements the temperature was not constantly increasing, as can be seen from the following list of the initial and final temperatures in each section:

Sect.	Measurement I.	Measurement II.
1	16.8° — 17.6°	16.5° — 19.3°
2	18.4 — 17.4	20.3° — 23.3°
3	15.3 — 20.2	14.9 — 20.5
4	21.2 — 23.6	22.3 — 26.1
5	15.7 — 15.4	16.3 — 16.7
6	15.8 — 22.9	17.9 — 20.4

According to this the temperature during the measurement of sections 2 and 5 has decreased in the first measurement and increased in the second. In section 6 the increase in temperature at the first measurement was 7°, at the second only 2.5°; in spite of this large difference in the increase of temperature both measurements agreed within 1 m m. (0.0393 in.) Therefore an influence of rapid increase in temperature upon the result of the measurement cannot be deduced from the above figures. If we consider that 1° C change in the mean temperature of the rod changes the length of the same from 4 to 5 m m (0.157 to 0.196 in.) we are justified in concluding that the thermometers indicated the mean temperatures of the rod very nearly correctly and that the errors caused by the uncertainty in the temperature observations are to be taken as accidental errors. The thermometers are divided directly into fifths of a degree and the tenths can easily be estimated. If it should still be insisted upon, that the fact, that the measurement was done principally during the increase of temperature, *may* have caused a constant error, it must be considered, that this error must have been too small to affect the result to any extent. The influence of the temperature upon the measurement will be made clearer yet, if in future base measurements the observations could be so arranged that they would be made partly at increasing and partly at decreasing temperatures.

It may be asked why not, as formerly was the custom, use the expansion of the rod itself as a means of determining the temperature. In answer to this we must first consider that if the rod is made of two metals, say of iron and zinc, as in Bessel's apparatus, an error caused by 1° difference in temperature between the iron and zinc has nearly twice as great an influence as when the mercury thermometer shows the mean temperature of the iron rod 1° too high or too low; because the zinc expands from three to four times as much as the iron. In a very interesting report of Professor Jordan (Zeitschrift der Vermessungskunde, October, 1880,) on the measurement of a base near Gottingen in Hanover, in August, 1880, by the Prussian general staff under Lieut. Col. Schreiber, and with a Bessel apparatus, it is stated that a change of 1° R. in temperature altered the base by 0.000023 of its length.

Prof. Jordan says further: "From this we can conclude that the errors caused by the uncertainty of the temperatures of iron and zinc are equally as large as the direct errors of measurement." Lieut. Col. Schreiber says: "The zinc always runs ahead, whether the temperature increases or decreases. The errors caused by the uncertainty of the temperatures of the two rods are so great that the signs of the difference of I minus II measurement can be predicted for many sections in advance, if nothing else is known than the observation of the metal thermometer."

In Bessel's apparatus the two metal rods are enclosed in wooden boxes, which are exposed to the direct rays of the sun. In Ibañer's apparatus the rods are uncovered, but the measurement is done under tents. At Bessel's measurement in Eastern Prussia and at the one at Gottingen above mentioned mercury thermometers lay in the boxes near the rods. In both cases it was proven that when the boxes became warm the thermometers answered quicker than the rods. This experience makes still more improbable the assumption that at the Aarberg base the massive iron rod followed changes of temperature quicker than the thermometer. We can, therefore, state that no important influence of the changes of temperatures upon the results of the measurements has been observed at the three measurements of the Aarberg base. It is remarkable that 75 per cent. of the corresponding differences of the temperatures and measurements have unequal signs, or in other words, that a short measurement corresponds to a higher temperature.

In connection with the question of temperature, so important in base measurements, it will be of interest to mention the answer Gen. Ibañer gave to the writer upon a question directed to him:

"The simple arrangement of my apparatus and the manner of its use is the result of experiences gained at nine base-line measurements, made by me in Spain. My first apparatus had all possible arrangements for corrections; the rod consisted of two metals; the difference in their lengths, in consequence of changes in temperature, was measured by micrometer screws. Mercury thermometers, fastened to the rods at equal intervals, furnished a second method of determining the temperatures independent of the first. I soon learned that the observations with the mercury thermometer were made quicker and more reliable than those with the metal thermometer, so that I abandoned the latter. The effort to measure every length and each correction separately by the micrometer screw, as we did at first, is the cause of great delay and much labor without real gain in accuracy. The complication and time consumed in measurement neutralize a great many of the advantages gained. The best remedy to avoid the accumulation of errors of observation in extensive triangulation is the measurement of a sufficient number of base lines. The more simple the apparatus and its handling the more frequently can this remedy be applied."

The advantages of Ibañer's apparatus, which were so apparent at the Aarberg base line, are principally the simplicity of the apparatus itself and of all the manipulations, excellent organization, careful preparation and the systematic proceedings during the measurement. The iron rod is very strong and durable; the exact lengths are marked by lines engraved a short distance from the edge of the rod, thereby avoiding disturbances and changes during transportation and use. The rods are not brought in direct contact, which is always a source of error and requires great skill in the assistant, but the measurement is done by means of very simple microscopes. Each microscope has two parallel wires, the correct position of which can be checked at each observation by means of a mark made by the maker, and between which the graduation of the rod is set. Assuming that the naked eye is able to accurately estimate 0.2 to 1.0 m m (0.008 to 0.004 in.) with a microscope (of 20 diameters) at least to 0.02 to 0.01 m m (0.0008 to 0.0004 in.) can be read. Even assuming the mean error of the microscope to be 0.02 m m (0.008 in.) its influence upon measurement of 1000 m (3280 ft.) or 250 lengths of rod with 500 settings of the microscope would amount only to $0.02\sqrt{500} = +0.45$ m m (0.0175 in.) Therefore, the error of observation in consequence of the uncertainty of the setting of the microscope will not amount to more than half a millemetre per kilometre (0.0195 in. in 3,280 ft.) even if we make the above unfavorable supposition. The difficult and long operation of plumbing is entirely avoided and replaced by a very ingenious, optical operation. The marking of the monuments is done in a very simple and safe manner, so that the number of monuments can be increased without delaying the operation too much. In the case before us we have the following comparison of mean errors calculated from the differences in the six sections and in the entire length of base.

For measurements I and II. For all 3 measurements.

$m_1 = \pm 1.2$ m m (0.0468 in.) $m_2 = \pm 1.2$ m m (0.0468 in.)
$m_3 = \pm 1.1$ m m (0.0433 in.) $m_4 = \pm 1.6$ m m (0.0627 in.)

In reference to the time, the measurement required, it has already been said that 100 lengths of the rod on an average of the first measurement took nearly 150 min., or one length 1.5 min. The total operation could have been done in half the time, if only the time, but not the fatigue of the operators had been taken into account.

It is interesting to hear what Prof. Jordan says about the time required for the above mentioned Gottingen base. He says:

"The Gottingen base was measured, after three days preparatory exercise and practising, first in three full and two half days, and the second in 2.5 days. The maximum progress in one day was 131 lengths. To show the increase in the rapidity of measuring the different base lines we mention the following measurement of one day:

1834	Konigsberg	68½	length of rod =	1071 metres.
1871	Braak	67	" " =	1015 "
1872	Grossenheim	88	" " =	1373 "
1877	Oberburgheim	113	" " =	1763 "
1880	Gotlingen	131	" " =	2044 "

When everything was working smoothly one length of rod required 4.5 min., while the average was about 5 min.; 4½ min. for one length of 15.6 m. (51.17 ft.) is a greater rapidity than accomplised in other base-measurements. This rapidity is of great importance, as then all the small changes of temperature, disturbance of the supports, which cannot be avoided in most operations, are all of less damaging influence, than in very slow measurements, provided always, of course, that the haste is not too great. This latter was not at all the case in the Gottingen base; the rapid progress was not obtained by any undue haste, but by well advised systematic proceeding, careful preparation etc. The strict military organization of the party (15 officers and 50 assistants) is one of the principal reasons for this admirable result."

On account of the great rapidity, with which base-measurements are now made, the question has been raised, whether it would not be advisable to return to the measurement of long bases, in order to easier connect with triangles of the first class. Aside from the fact, that it will always be easier to find room for a short base, the question of expense will also have effect in the matter. As shown above, it is possible to determine from a short base a very much larger side of a triangle with sufficient accuracy. The cost of base-measurement amounts to from 500—600f. ($100—120) per day. For the measurement of the adjoining triangles we have to count on from 40—50f. ($8—10) per day. Therefore the cost of each day of base-measurement corresponds to that of 10—15 days of triangulation. In this case a base of double the length would correspond with two or three months time of the adjoining triangulation. It is therefore apparent, that it is more economical, to double the length of the base by triangulation, than by direct measurement, provided that the latter would have been possible at all.

The question was raised as to how accurately the base of 2400 m. (7872 ft.) could be measured with common measuring rods. The writer measured the base three times with common 5 m. (16.4 ft.) long rods, 4 cm. (1.57 in.) thick in the middle and 2.5 cm. (0.97 in.) thick at the ends. The rods were compared previously to and right after the measurement, with the Swiss standard; the reduction upon a level was made according to an average inclination, ascertained from a longitudical profile of the line. Every 200 m. a peg with a small tack was driven. The line was measured three times along stretched cords. From the three measurements of the 12 sections, each 200 m. long, we computed admissable error for one measurement for 1 m. $= \pm 0.28$ mm. (0.0109 in.) Then the total error for the base would be not more than 14 mm. (0.55 in.) In reality the results were as follows:

Rod-measurement	minus	Base-measurement
At 400 m.		+ 0.006 m.
" 800 "		− 0.019 "
" 1200 "		− 0.043 "
" 1600 "		− 0.065 "
" 2000 "		− 0.075 "
" 2400 "		− 0.085 "

Apparently the deviations were caused by a constant source of error, and as the true lengths are greater, this source was very likely caused by adopting too great a length for one rod, as all the other sources of errors, as the deviation from the straight line and from the level, moving of one of the rods while laying down the other etc., would cause errors in the opposite direction. It is probable, that the two rods together were from 3 to 4 m m. too long. This, however, should not be attributed so much to a mistake in comparison with the standard, as to the changes caused by the rain, direct rays of the sun etc. We may, therefore, conclude, that a line cannot be measured with common rods closer than within 1-2500 of its length.

Through the kindness of Professor Wolf, the writers' attention has been called to the fact, that not only does the principle of Ibañer's apparatus correspond with the one of Hassler, but that also the Bern base measured in 1834 by Messrs. Eschmann, Wolf and Wild, had been previously measured at the end of last century, by Tralles and Hassler with Hassler's microscopical apparatus. The latter is described in "Papers on various subjects connected with the survey of the coast of the U. S., by F. R. Hassler, Philadelphia, 1824." On page 86 he says: I shall add a few remarks about a base, 42,000 feet long, which I measured in the year 1791 and 1797, in connection with Tralles. This base was measured twice, the

first time with a chain, similar to those made by Ramsden, for the English land-surveys, and the second time with an apparatus of rods of 4 toises length (one toise equal to 6.39 feet), which I have described above. The remarks following refer mostly to the establishment of intermediate points, so that the operation, in case of accident, may be taken up again at such points. He then emphasizes the necessity of examining and adjusting each part of the apparatus before each measurement, gives instructions about keeping the notes and concludes with the following remarks: "The measurement of a base should be made with as few interruptions as possible. All greater disturbances, rapid and uneven changes in temperatures etc., should be strictly avoided. I would advise, to finish each day's work (the base being previously divided into sections) without interruption, and if this is not possible, rather to wait for a more favorable time." Nearly a century has elapsed since Hassler measured his base. The progress made since then by Gen. Ibañez is very great and important. Hassler still used the plumb-line to transfer the monuments and end-points. The objective glass of his microscope consisted of two half lenses of different focal distances, so that the end of the 8 m. rod, marked by a stretched spider-web, could be brought in co-incidence with the mark upon the tripod. The movement of the rod was complicated; the rod rested upon 3 different supports, permitting movements in two directions, at 90° to each other. The whole apparatus was enclosed in a wooden box, on one end of which a telescope and on the other end a sharp point was fastened.

Hassler's measurement with this apparatus corresponded very nearly with the one of 1831.

THE OHIO RIVER FLOODS.

Col. Wm. E. Merrill, U. S. Engineer, in replying to the enquiries and suggestions of our correspondent "T. L. M.," in a late number of ENGINEERING NEWS, sends us a letter written by him to the Cincinnati *Commercial Gazette*, upon the subject of the Ohio River Floods. We make the following extract from it:

"The country above Cincinnati, which is drained by the Ohio, is composed of the western third of Pennsylvania, the whole State of West Virginia except the four counties at the northern end of the valley, the eastern part of Kentucky, and the greater portion of the State of Ohio. The whole of the left side of the valley of the Ohio is hilly ground, culminating in the Allegheny Mountains. The right side is hilly near the river, but a short distance back it is a rolling table-land, nearly flat, and admirably adapted to agriculture, nearly the whole region being cleared and cultivated.

"In discussing the question of the effect of forests on floods, it is conceded by all that flat lands must be cleared and cultivated whether floods are thereby increased or not, for the simple reason that no nation can live without agriculture, and cereals cannot be grown in forests. At the same time all experience proves that the clearing and cultivation of level land has a comparatively small effect on floods, and may be left out of consideration. The disastrous effects of the removal of forests are not felt until the axe and plow have ascended the hills and mountains, removing the covering that protected the soil, and permitting the latter to wash away and choke the water courses.

"Any one who travels on the railroads that cross the Alleghanies knows that the country through which they pass is still heavily wooded, with practically no clearings except in the level bottoms.

"If I understand the forest theory correctly, no particular damage is done by the removal of merchantable timber provided the underbrush and less valuable trees are permitted to remain, so as to cover and protect the soil. Danger begins when the forest is permanently removed, and the ground is bared for cultivation or pasturage. Judging from an extended knowledge of the States of Pennsylvania, West Virginia and Kentucky, we are yet very far from having attained that state of forest destruction that would require the intervention of the Government for the protection of the river valleys. It is not the axe of the woodman that is to be feared, but the plow of the farmer. When the hillsides and mountain tops of Pennsylvania, Ohio, West Virginia and Eastern Kentucky are covered with farms, and forests become rare, then the cities of the valley will have to look out.

"We must also bear in mind the fact that the traditions of the Aborigines show that even the great flood of 1884 was equaled by floods that occurred before the white man's axe had felled a single tree in the Ohio Valley.

"Many persons think that it may be possible to build reservoirs to contain the surplus waters of floods, and let them out gradually after the rivers have returned to their banks. This theory unfortunately fails when tested by the inexorable logic of figures. Many years ago a favorite scheme for the improvement of the low water navigation of the Ohio was to build a number of reservoirs in the mountains to store up the surplus water of spring, and let it out during the scarcity of summer. The idea is an old one, that has been discussed and abandoned as impractical in the case of many European rivers; it was brought forward in this country many years ago by a very able engineer, Mr. Charles Ellet., Jr., and was vigorously pressed on Congress.

"When the subject of the improvement of the Ohio River was taken up by the Government, after the close of the civil war, it became the duty of my predecessor, Mr. W. Milnor Roberts, to look into this theory. After an exhaustive examination, the details of which are given at length in his report to the Chief of Engineers, dated April 30, 1870, he concluded as follows:

"'My own careful investigations of the subject of controlling the floods of the Ohio by means of artificial reservoirs, which were made in 1857, satisfied my mind conclusively that such control by any human means, attainable within practicable limits of cost, is impossible.'

"He then took up the much smaller plan of storing up enough flood-water to provide for the deficiency in summer months, so as to make a summer flow at Wheeling of six feet. Careful calculations showed that reservoirs for this purpose would have to supply storage for one hundred and fifty thousand million (150,000,000,000) cubic feet of water, and it was assumed that this immense body of water could be held in six reservoirs. Each reservoir would have to be built where it could receive the drainage of at least six hundred square miles, and the slope of the valley would have to be less than four feet per mile, so that a dam one hundred feet high could pond back the water at least twenty-five miles.

"After a careful examination of all the valleys of the streams tributary to the Allegheny and Monongahela, Mr. Roberts concluded that no such site could be found on any of them, but that it might be possible to build thirty smaller reservoirs that would accomplish the result, at an approximate cost of sixty millions dollars. The scheme was therefore abandoned.

"It may be worth while to add that even if reservoirs were practicable, they would flood farms, factories, towns and railroads; they would greatly interfere with rafting or any other kind of navigation, and they would be exceedingly dangerous. It would be vastly better to have an annual flood than to attempt to guard against one by such dangerous devices.

"The experience of all river men is that the river-bed is much wider (except at cities) than it was during the early settlement of the country. The removal of the timber that protected the banks has caused them to wash, and the area for the passage of the floods has been increased.

"At Cincinnati, however, the area has recently been contracted, and the process is still going on. I have protested against it from time to time, but being without power to stop the contraction, my protests have produced no results. I would strongly recommend that the State of Kentucky and Ohio appoint a joint commission to define the lines of high and low water along the city front, and that it be made the duty of some public officer to prosecute in cases of encroachment. Without some such provision the work of the Commission would be ignored, as is the case at Pittsburg, where similar lines of high and low water were laid out by authority of the State of Pennsylvania.

"It is evident that if the channel at Cincinnati were now much obstructed the effect would be to hold back the flood for cities below. As no such effect was observed it necessarily follows that the obstruction is not yet very serious; nevertheless I still think it advisable to put and end to enroachments on the bed of the river by the means that I have indicated.

"It has been suggested that possibly the bed of the river has been raised by deposit. To that I have to say that comparison with the oldest accessible maps does not show any such change, and it certainly has not happened at this locality, as is proved beyond doubt by the rock bar at the mouth of the Licking. Were there any deposit in the bed of the river at this place we would find sand and gravel over this rock, which is not the case. Similarly there has been no deposit over the rocks at Louisville, and, having shown that these two points could not have changed, we are necessarily compelled to acknowledge that no important change could have taken place in the bed of the river between them.

The practicability of filling up the lower plane of the city is one of the questions of the hour, and our neighbors in Kentucky are much exercised on the possible injury to their interests if the project is carried out. Suppose, for instance, that Main Street north of Front was raised above this year's flood. The effect of this would be to cut off the flow through Second and through Pearl streets and to add it to the main river. There would be no other effect, as there was no flow through the squares occupied by buildings, and back-water has no influence. Theoretically, the line of the river would be raised; practically, the raising would be imperceptible. My conclusion is that if the lowlands of the city were raised by continuing the present slope of the wharf upwards until it got above high water line at Second street, or at any point between Front and Second, the effect on floods would be inappreciable, but any building out in the river would be inadmissable.

The construction of a levee along the city front would be exceedingly expensive, especially on account of the necessity of cutting off the outlets of the present sewers, and of building a large intercepting sewer, with sewage pumping works at the outfall.

Considering the cost and the taxation that must go with it, I would prefer, if a property-holder in the submerged district, to submit to a quiet rise of the waters rather than risk a levee with its attendant dangers and cost, and its obstruction to business.

In my judgment, the easiest and cheapest plan is to abandon the bottom to business, and build all houses with a view to possible floods. Well built brick or stone houses have invariably withstood the floods without other injury than a wetting. I would recommend that the second stories be placed at least two feet above the flood line of this year, that extra good foundations be secured, that the walls be laid in cement, and that they be made thick enough to carry on the second floor everything that would have to be placed there when the lower floor was abandoned. The most important point is to get the laboring people away from the flooded district so as to lesson the appeal for charity, which cannot always be met with the abundant resources that were poured out this year and last.

WM. E. MERRILL,
Lieutenant Colonel of Engineers.

WHETHER the United States are to regain their former pre-eminent rank as a commercial and naval power on the seas, is a question that no American can contemplate with indifference. The subject is discussed with marked ability in the *North American Review* for April, by the Hon. Nelson Dingley, M. C., who opposes the project of admitting foreign-built ships to American register, and by Captain John Codman, who is well known as a zealous advocate of that measure. Judge J. A. Jameson, in the same number of the *Review*, discusses the question, "Shall our Civilization be Preserved," pointing out the means that are at hand for withstanding the various agencies, physical, moral and intellectual, which threaten to overturn our existing civil and social institutions. The Rev. Dr. Philip Schaff gives a sketch of the "Development of Religious Freedom." Dr. Felix L. Oswald writes of "Changes in the Climate of North America" with special reference to the increasing frequency of disastrous floods. Prof. C. A. Eggert offers "A Plea for Modern Languages" in the higher education; and Julian Hawthorne discourses of "Literature for Children." Finally, there is a discussion of "Recent Criticisms of the Bible," by the Rev. Dr. R. Heber Newton and the Rev. A. G Mortimer.

ST. PAUL, Minn., Mar. 10.—In Minneapolis to-day the officers and Directors of the Minneapolis, Sault Ste. Marie & Atlantic Railroad held a special meeting at Gen. Washburn's office. There were present: Gen. Washburn, Capt. Martin, Thomas Lowry, Capt. Merriman, John S. Pillsbury, H. E. Fletcher, J. K. Sidle, C. J. Martin, M. P. Hawkins, and W. W. Rich. The most important business of the session was the discussion on the subject of buying rolling stock. The result was that the President, Gen. Washburn, was authorized to make contracts for rolling stock, to what amount the officials decline to make public at present.

A STOCK company with a capital of $100,000, and with shares at $10 each, has been formed for the purpose of working the Maddox granite ledges at Amherst, N. H. A steam engine and drill have been put in, and work will commence early this spring.

THE Fourth Annual Meeting of the American Water-Works Association will be held at Cincinnati, Ohio, on April 15th. The Secretary is Mr. J. H. Decker, Engineer of the Hannibal, Mo., Water Works.

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THE Philadelphia councils in their endeavor to shield the public from injustice, in the execution of contracts submitted some very harsh conditions to be complied with. Wm. Sellers the President of the Edgemoor Iron Company in submitting a proposal to do city work, says that he must decline to furnish the character of security, demanded by the ordinances of Councils. "No contractor, with a particle of self-respect," he says, "would deliberately place himself in the category of criminals by agreeing to terms and conditions which are only demanded of parties who have given evidence of attempting to commit a criminal action." He further states that "the ordinances now in force concerning the methods of making contracts are harmful to the city's best interests because they deter the best bidders from making proposals."

THE TEHUANTEPEC SHIP RAILWAY.

London *Engineering*, of February 22, has a long editorial upon the Ship Railway project of Mr. Eads. It commences by describing the geographical surroundings, and the results expected from the completion of such a railway. *Engineering* thinks that a work designed to effect such enormous benefits to the commerce of the world should commend itself, especially to England, which carries 60 per cent. of this commerce.

Mr. Eads is evidently pushing this matter in England with his customary vigor, and, according to the journal quoted, will in a short time present the subject to the attention of British capitalists and ship owners. *Engineering* refers in terms of praise to the professional standing and experience of the American civil engineers who have had the field work in charge. Mr. E. L. Corthell, the Chief Engineer, Mr. M. Van Brocklin, Resident Engineer, M. de Garay, Mr. I. I. Williams, and Mr. Deming I. Thayer.

In regard to the proposed line, gradients, construction, etc., we have already, in our numbers of July 28 and October 13, of 1883, given fuller details than contained in the above article.

The City Engineer of Boston.

The Boston *Herald*, in a late edition, gives a sketch of the multitudinous duties of the engineer of that city, and also a list, with salaries paid, of the assistants to the chief.

According to the *Herald*, the first City Engineer of Boston was Ellis S. Chesbrough, who served from 1850 to 1855. He was succeeded by James Slade, who held office until 1860, when N. Henry Crafts was elected. Mr. Joseph P. Davis succeeded Mr. Crafts in 1872, and held this position until his resignation in 1880, when the present City Engineer, Henry M. Wightman, was elected his successor. The present salary of the City Engineer is $4,500 per annum.

The office of chief assistant was held until very recently by Mr. Alphonse Fteley, at a salary of $3,300 per annum. Mr. Fteley is now chief assistant to the engineer of the Croton Aqueduct Commission, at a much increased compensation.

The other assistants are, John E. Cheney, chief draughtsman and designer of iron bridge work; Mr. Henry Manley, in charge of all tide-water and inland bridges; Mr. Dexter Brackett, in charge of the distribution system of the water supply and the water meter system; Edward W. Howe, in charge of public park construction and in addition to these there is a regularly engaged engineering corps of 12 or 15 men.

The improved sewerage department is in charge of Mr. Eliot C. Clarke, at a salary of $3,000 per annum.

American Society Civil Engineers.

Notwithstanding the inclemency of the weather on Wednesday evening, there was a fair attendance at the meeting of the society. Vice-president Paine was in the chair.

"The Comparative Liability to, and Danger from, Conflagrations in New York and London" by E. B. Dorsey, was the title of the paper read. Capt. Shaw, the Chief of the London Fire Department, when on a visit to this city about two years ago, stated that the cause of the comparatively few fires in that city was the superior efficiency of the English fire "laddies," and this statement Mr. Dorsey undertook to disprove. The climate of London, he said, was very damp. During the 11 years from 1871 to 1881 it rained on an average more than three days a week, and the sun was seen but about one-quarter of the time. The temperature of London only lacks 18 per cent. of total saturation, and the wood in the buildings is so damp at all times that sparks or weak flame will not ignite it. The average winter temperature of London is 6½° higher than in this city, and this fact makes it unnecessary to have so many fires in the houses for warming purposes. Many of the conflagrations are caused by these domestic fires, and the statistics of the department here show that in the three winter months there are one-third more fire alarms than in the nine warmer months. Again, the population in the densely settled district of New York is greater than in London, averaging 352 persons to the acre to 249 in London. This excess of population requires larger and higher houses, and consequently a greater concentration of combustible materials.

The average London house is much smaller than in this city. Probably 60 per cent. of the buildings are less than 15 feet wide, 25 feet deep in the clear, and 22 feet high, and contain less than 3,000 feet of lumber. In most of the larger houses and many of the smaller ones the partitions and staircases are of brick or stone, and in all cases there is proportionately less wood and more brick or stone than in New York dwellings. The walls being low and firm, they do not fall when the wood-work burns, and the firemen can approach them without danger. London is divided into small fire districts by numerous parks and private grounds, the Thames, and a great number of railroads which terminate in the city, and cemeteries, which confine a fire when started, to its own little district, and thus greatly aid the firemen. Mr. Dorsey gave a great many statistics in regard to the population and buildings of London, and his paper was listened to with attention.

In the discussion which followed, Inspector of Buildings William P. Esterbrook said that the building law in this city was a very curious thing. Under it a man may erect a ten-story frame building on Broadway, and all that can prevent it is the will of the Inspector of Buildings. The reason the city did not have a good building law, he said, was because the people were not educated up to the necessity for one and architects and builders, strange to say, deemed it for their interest to oppose anything like a strict one. Several measures were before the Legislature, but they were being opposed violently. Mr. Esterbrook added that many of the so-called fire-proof buildings in New York were shams.

The paper was discussed by several members, and the meeting adjourned at an early hour for conversation.

PHILADELPHIA WATER SUPPLY.

Colonel William Ludlow, Chief of the Philadelphia Water Department, in a speech before the Board of Trade of that city on the question of an adequate water supply, said that the inadequacy of the present facilities was a very serious subject and demanded much more attention than was given to it. In the Sixth Ward alone $65,000,000 of merchandise, bank notes, stocks, etc., were subject to fire risks, when water is extremely scarce. In the limits of the "old city" there is $100,000,000 worth of merchandise in course of daily exchange $15,000,000 in permanent storage, besides $120,000,000 in buildings, representing a total of $235,000,000 subject to the risks of a deficient water supply.

Colonel Ludlow said that most of the pipe in that section of the city, with such an enormous amount of property to protect, has been in the ground since consolidation—1854—and is entirely too small. Some of it has been in the ground so long that the accumulations on the inside from incrustation have converted a four-inch pipe into, in some cases, less than an inch and a half, and one section of pipe was shown, in which the incrustation had become so great that the hole through which the water could run was scarcely large enough to allow the entrance of the little finger. In some cases the fire hydrants are attached to pipes from whence no supply can be obtained. Now no pipes less than six inches are laid, as a smaller pipe is considered insufficient, and all pipes less than that should be condemned. There are in the "old city" 2,158 feet of 1½-inch, 1,650 feet of 2-inch, 120,400 feet of 3-inch and 27,133 feet of 4-inch pipe—in all 150,000 feet of pipe less than 6 inches, which should at once be replaced. Of 6-inch pipe there are 209,000 feet; of 10-inch pipe, 20,000 feet; of 12-inch pipe, 44,350 feet; of 16-inch pipe, 11,833 feet; of 20-inch pipe, 19,833 feet, and of 30-inch pipe, 17,644 feet, all of which have been down from twenty to sixty years.

Colonel Ludlow then proceeded to show that it was impossible to get sufficient pressure upon most of these pipes to supply water to the third stories in some sections, and in many cases to get any reliable fire service from them. It was shown that the supply of water to the pipes was greater than could be transmitted through them. The pipes cannot carry the water, and in consequence the owners of property are paying for appliances which are seldom in use.

The first thing to be done is to replace this

inadequate pipe, then the city should be divided into grand squares, each of which should be surrounded by large pipes. Particular stress was laid upon the necessity for stopping the waste of water, which amounts to 35 per cent. of the pumping every day. It was shown that since consolidation the receipts of the Water Department exceeded its expenses $8,750,000, from 1873 to 1882, $5,474,322, and in 1882 the profits were $855,946; in 1883, $579,842, and this year they will be $886,500. It was estimated that it would require about $6,000,000 to do all the work that was necessary.

Colonel Ludlow proposed that the charge for the department be taken out of the tax rate and the water furnished charged to the consumer; that the department collect its own revenues and apply the profits to the necessary improvements until all shall have been made. Then the water rate can be reduced or the surplus turned into the city treasury. It was estimated that in from ten to fifteen years all these necessary improvements can be completed. Among the improvements recommended by the Chief Engineer is the building of a new reservoir at Thirtieth and Cambria streets and the completion of a part of the Park reservoir.

Boston Society of Civil Engineers.

The annual meeting and supper of the Boston Society of Civil Engineers took place at Young's Hotel Wednesday evening. The following officers were elected for the ensuing year: President, George L. Vose; Vice-President, L. Frederick Rice; Secretary, Horace L. Eaton; Treasurer, Henry Manley; Librarian, Charles W. Kettel; Auditor, Edward W. Howe. The annual report of the Board of Government, and also a report on instructions in the metric system were rendered and proved satisfactory. Among the guests at the supper were General Francis A. Walker, Edward Atkinson, Major C. W. Raymond, and J. J. R. Croes, Treasurer of the American Society of Civil Engineers.

The Civil Engineers Club of Cleveland.

This Society held its fourth annual meeting and banquet on the evening of the 11th in the rooms of the Windsor Club. The following officers were elected for the ensuing year:

President—J. F. Holloway.
Vice-President—B. F. Morse.
Corresponding Secretary—A. Mordecai.
Recording Secretary, M. W. Kingsley.
Assistant Recording Secretary—F. C. Bate.
Member of the Board of Managers of the Association of Engineering Societies—M. E. Rawson.
Treasurer—G. A. Hyde.

INTERESTING TO TOURISTS.

The Gettysburg and Harrisburg Railroad is the most important short line built in Pennsylvania within the year.

It is 31½ miles in length, and runs from Carlisle, on the Cumberland Valley Railroad, in a general southerly direction to Gettysburg.

The first ten miles of the route is over the South Mountain road (a line built from Carlisle to the Pine Grove iron furnaces) to Hunter's Run, thence it turns more directly south, and begins to ascend the South Mountain.

For about five miles after leaving Hunter's Run the road winds in and out of the hills composing that ridge until the summit is reached, 1000 feet above tidewater. On the other side of the mountain the slope is more gradual, and the grade becomes less steep until Gettysburg is reached.

The road is built in the most substantial manner, with stone ballast and steel rails and everything of Pennsylvania standard.

The trestles are double in all their parts, and are said to be the strongest in this country. By this road Gettysburg is but forty-nine miles from Harrisburg, and can be reached in two hours, thus making it accessible to the traveller, without inconveniencing him. Till now Gettysburg "the shrine of the late war" has been a sealed book to those most interested.

The opening of this road on the first of April will enable everybody to get in and out of Gettysburg by way of Harrisburg quickly and with comfort.

James McHenry on Railroading in America.

According to a recent interview in the N. Y. *Sun*, Mr. McHenry thinks railroad management in America susceptible of considerable improvements.

After stating that more than one hundred millions of dollars of European capital have been invested, through him, in American railway securities, and with bad results, he gives some of his reasons why railroads in this country are not more remunerative to the original shareholders.

He estimates the cost of running a train, fully loaded, at 50 cents per mile, including all expenditure of every kind. Hence, $500 should carry a loaded train to Chicago, and as the freights cannot average less than $4 per ton, the receipts should be, on an average of 400 tons, $1600, leaving a percentage of profit unparalled by any other legitimate business.

He argues from this that carrying rates for both freight and passengers should be greatly reduced, and the undeveloped traffic of the country be thus developed. That with present exorbitant prices, in proportion to cost, the number of travellers and the amount of freight surpasses the existing facilities for transportation. He refers to the elevated railroads of New York as an example of development; roads which now carry one hundred millions of passengers annually, and this in the face of an increased surface traffic. He thinks it would be both wise and profitable to put on cheap trains to Chicago, at say $4 or $5.

He charges that too many of our great corporations are eaten up by inside monopolies and parasites, fast freights and the like; that the knowing inside ring is thus enriched at the expense of the confiding stockholders. Mr. McHenry ridicules the statement that a railway company could not transact an express business for less than 40 per cent. of gross receipts; the reasons given by a prominent railroad for farming out this traffic at 60 per cent.; he says the actual cost is below 4 per cent.

He is very severe upon Commissioner Fink and his pool; declaring that the "cutting of rates," "short crops," &c. are mere phrases generally invented to cover speculative management; and that pools are established, broken up and reconstructed simply to increase ring profits. Competition of the cheapest kind he thinks is conducive to a final healthy growth and to progress.

Throughout the entire interview Mr. McHenry is bitter and sweeping in his charges; and while taking into consideration his personal animus and experience in American railroading, which has not had a tendency to sweeten his temper, we must admit that there is much truth mixed with this tirade of fault-finding.

The management of modern railroads, from a Wall Street standpoint, is a thing past finding out by the outside public who furnish the ready cash; the latter must generally invest on faith simply, and just now the lambs have lost all faith in corporations, and hence the present so-called "stagnation" in the railroad world.

There are mysteries in the management, difficult of honest explanation; the colossal wealth of railroad kings and manipulators is a prominent one. Many of the officials of this day, too, could give "Poor Richard" points in economy; and would confer a blessing on the would be rich, by initiating them into the secret of accumulating millions on a fixed salary of a few thousands.

Mr. McHenry has pointed out some of the parasites which grow fat on a small dividend-paying corporation, and which constitute other of the "mysteries." And in referring to rates he very pointedly asks why a barrel of flour can be carried from Chicago to New York for 70 cents, and a man is charged $16 for the transportation of a comparative like dead load. We will admit that the man takes up more room and requires more luxurious surroundings, but the disproportion of one man to twenty-three barrels of flour leaves an unexplained margin of transportation cost.

That more people will travel if it costs less is a proven fact; and that corn would be sent to market instead of being burned is also undeniable, did it not happen that it was sometimes cheaper to burn it. The tendency to "cut rates" should then be encouraged, but they should not be cut simply to make a deal, and then again raised to a point prohibitory, but put down to figures fixed by an honest equation of actual cost and reasonable profit. As it is, the shareholder is well content with his five or six per cent., and is considered lucky if he gets it; the extra dividend, which should represent lower rates and greater facilities, is now diverted into other channels, some of them foul enough.

There are railroads and there are railroads, but there are too many railroads whose only purpose is to add to the wealth of the few at the expense of the multitude, and by their combinations and manipulations interfere with the welfare of more honestly managed corporations. It is to this, too common class, Mr. McHenry refers and to this class that our general remarks apply.

THE LONDON SEWERAGE QUESTION.

The last number of the *Contract Journal* (London), in speaking of the sewerage of London, says that that city, with the most remarkable sewerage system in the world, is still in trouble as regards the disposal of the sewage.

Twenty-three million cubic feet of sewage are daily poured into the Thames, but the tides bring a great deal of this matter back to within a short distant of London Bridge. It is estimated that of the 446 tons discharged per minute by the numerous sewers, an amount equal to 1,250,000 tons per year is mud, which enters the river mainly from the Barking and Crossness sewers. Much of this solid matter is harmless, beyond the silting up of the river bed, but it also contains much objectionable matter that had better be further removed from the city.

The Royal Commission, appointed in 1882 to look into this question, have made their first report, and, while they praise the system of drainage works carried out under the direction of Sir Joseph Bazalgette, admit that the London sewage is having a serious effect on the purity of the lower Thames and its tidal banks.

The Committee can as yet suggest no remedy, except that in their opinion material advantage would be gained by carrying the sewage still further down the river. The original design was to discharge the sewage only on the ebb tide, but the vast increase in quantity has made it necessary to break this rule. Larger reservoirs, to cost $800,000, have been planned, but they promise to only partially relieve the evil. The one great objection to extending the outfall system is the pumpage that would thus become obligatory to obtain the required flow.

The Engineers Mansergh and Melliss, called in to consult with the joint board of the Lower Thames Valley District, propose chemical precipitations at Mortlake, Hampose or Barnes; but land owners object, and a double drainage system would be required, separating the storm water from the sewage. The quantity to be dealt with, 446 tons per minute, is the great ob-

stacle; and, as finally reported, the whole question is at a deadlock again, with no feasible way out of the scrape.

PERSONAL.

W. A. SOMERS was unanimously re-elected City Engineer of St. Paul, Minn. on the 11th.

JESSE R. STRAUGHAN has been appointed City Engineer of Fort Wayne, Ind., to fill the unexpired term of W. H. GOSHOW, resigned.

JONATHAN DWIGHT has been appointed Chief Engineer of the Central Massachusetts Railway Company, and will immediately examine the line from Cambridge to Northampton, with a view to the preparation of specifications for contractors.

THE officers of the New York and Connecticut Air Line Railway Co. are: S. E. Olmstead, President; C. V. Sidell, Treasurer; T. H. Brown, Secretary, and N. B. Schubarth, Chief Engineer, the latter with headquarters at Norwalk, Conn. The road is now in progress of construction.

CAMPBELL W. ADAMS, C. E., has been appointed city engineer and surveyor of Utica, N. Y. for his fourth term—a satisfactory testimony to his abilities as an engineer and popularity as an official.

G. W. PEARSONS, of Kansas City, Neb., well known as a successful hydraulic engineer, was in the city this week on business connected with the Kansas City Water Works, of which he is the Chief Engineer.

MR. SETH H. INGALLS, an old citizen of New Bedford, Mass, died on the 18th. He was an architect by profession, and in his early days superintended the construction of several local railroads.

VICE-CHANCELLOR BIRD, of New Jersey, has denied the application for an injunction restraining E. F. C. Young, the Receiver of the Dixon Crucible Company, of Jersey City, from paying a dividend to the creditors of the concern. The profits of the business have amounted during the three years of Mr. Young's Receivership to $368,000. Of that amount, $221,000, has been paid in dividends. The balance of $147,000 represents, the Chancellor says, profits of the business, and the creditors are entitled to it.

WENDELL BOLLMAN, the well-known bridge builder, who died a few days ago in Baltimore, began life as an apothecary's clerk. Then he became a carpenter, although never more than a passable workman. He was afterward employed by the Baltimore & Ohio Railroad to notch ties, for which he was paid less than 50 cents a day. He was promoted rapidly by the railroad company until he became "master of the road." He built many notable iron bridges, and was probably the first successful iron-bridge builder in this country. He became known in other countries as a bridge-builder and inventor, and was invited to construct bridges in South America, Mexico, and Cuba. The present Harper's Ferry iron bridge was built by him. During his whole life he never ceased studying, and his collection of works on engineering is very large.

THE Legislature of Ohio has abolished the office of resident engineer of the public works of that State. They have thus thrown out Messrs. T. D. Paul of the first division; W. C. Safford of the second, and John W. Irwin of the third division. In their place three new superintendents are appointed. The act has been so amended by the Senate that it will not reorganize Chief Engineer J. B. Gregory out of office. His term expires May 22d. The act takes place March 25th, and is already a law by the concurrence of the House. It abolishes three resident engineers, and creates the office of a sistant chief engineer, and gives eleven superintendents, instead of nine, making the same number of offices as before.

MR. J. L. FOLSOM, master mechanic of the Boston, Revere Beach and Lynn Railroad since the commencement of that line, has resigned to accept the position of General Manager of a Western road, and leaves in a few days for St. Louis. Mr. R. D. SUTHERLAND of Lynn is his successor.

AMONG the visitors at the rooms of the American Society on Wednesday evening, was Mr. G. Knoche, Civil Engineer of the Prussian Government, Berlin, at present on a tour of observation of works of Civil Engineering in America. Mr. Knoche will remain several months in the United States.

MR. A. M. Wellington, late of the Mexican Central Railway, has returned to this country, and is now an assistant editor of the *Railroad Gazette*. He was at the rooms of the American Society of Civil Engineers on Wednesday evening, and in reply to our queries concerning his forthcoming book on Railway Location, said, that the book has been almost wholly re-written, is enlarged to probably double the size of the old volume, and that three-fourths of the manuscript is finished. It will be pushed as rapidly as Mr. Wellington's engagements will allow, and we will give our readers due notice of its progress.

OBITUARY.

Brevet Major-Gen. GODFREY WEITZEL of the U. S. Engineer Corps died at Philadelphia on Wednesday the 19th, at the age of 49 years. General Weitzel was born in Cincinnati, O., in 1855 he graduated from West Point, standing second in a class of 33; on July 1st of same year he was appointed Brevet-Second Lieutenant of Engineers, and to Captain on March 3, 1863. He served with distinction throughout the war of the rebellion, and was mustered out from Texas in February, 1866, as Major-General of Volunteers, and went back to his grade in the Engineer Corps of the regular army.

Gen. Weitzel served as Superintending Engineer of the construction of Forts Knox and Popham in 1866, of the improvement and survey of the Tennessee River from 1867 to 1871, and of the improvement of the Ohio River in 1869. He was engaged in various surveys and improvements of rivers and harbors in Eastern Michigan from 1873 to 1878, and was a member of the Board of Engineers on certain harbor imbrovements on Lake Michigan and Superior in 1870. He was also a member of a commission to devise means of protection for New Orleans wharves against the encroachments of the Mississippi River in 1878. He was made a Lieutenant-Colonel on June 23, 1882. His death will promote Major John M. Wilson to be Lieutenant-Colonel, Capt. William S. Stanton to be Major, First Lieut. Thomas N. Bailey to be Captain, and Second Lieut. Eugene J. Spencer to be First Lieutenant.

CORRESPONDENCE.

A METRIC "ENGINEER'S FIELD BOOK."

Special Correspondence Engineering News.

GLENWOOD, 23D WARD, PITTSBURG, PA., MARCH 10, 1884.

EDITOR ENGINEERING NEWS.—The recent successful completion of the main line of the Mexican Central Railway will certainly have the tendency to encourage further enterprises of a similar nature in Mexico.

As these will be very likely under control of American (i. e. United States) auspices, a new field for American engineers will thus be opened.

As the only legal system of weights and measures used in the construction of Mexican railroads is the Metric, a field book arranged according to this system would certainly be hailed with delight by engineers contemplating going to that country.

Why will not one of the authors of the numerous field books now used in the "States" take the initiative.

Surely such an undertaking would not be a *colossal* one and ought to be accomplished in a short space of time.

I also think that in the event of such a book being issued enough of copies would be bought by engineers interested in the Metric system to make the same a success, without a doubt, in a pecuniary sense.

E. L.

PROBLEM IN COMPOUND CURVES.

Special Correspondence Engineering News.

PHILADELPHIA, MARCH 10, 1884.

EDITOR ENGINEERING NEWS.—In your last number C. gives a solution to the question of "Subscriber" about compound curves. It is, however, not the right one, as the length of his curve is not equal to the portion of the location it replaces; the difference is more than 200 feet. C. has misunderstood the question, he forgets that the new curve must be of a certain length, and then the problem is not "undeterminated," but is evidently "too much determinated," as I have stated in my former letter. Yours respectfully,

E. THIANGE.

NEW "BLUE COPY" PROCESS.

Special Correspondence Engineering News.

CITY ENGINEER'S OFFICE, SOMERVILLE, MASS., Mar. 12, 1884.

EDITOR ENGINEERING NEWS.—I have lately discovered that white lines and letters may be made on a finished "blue copy," by using, as one would use ink, a solution of chloride of lime in water. Samples of lines and letters put on by this method are enclosed herewith.

The solution was made by mixing the chloride with about an equal quantity of water, shaking it, and allowing it to stand a few hours before using. It was applied with a drawing or writing pen, and allowed to stand till dry. The sheet was then thoroughly washed in water, the blue color washing off wherever the solution had covered it and exposing the white surface of the paper. I write this thinking that it may be new to your readers, and that it will be useful whenever it is desirable to add to a "blue copy" without altering the tracing, or to finish, for different purposes, several copies from the same tracing. The solution is also useful for erasing lines or figures in carmine, and in some writing inks.

Respectfully,

T. O. PERKINS.

HOW TO PRESERVE TIMBER SECTIONS.

Special Correspondence Engineering News.

ANDOVER, N. J., MARCH 10, 1884.

EDITOR ENGINEERING NEWS.—I would like to know how to get perfect sections or samples of native timbers.

There must be some process for seasoning them.

All I have become cracked, bark peels off and they become unfit for sawing.

I take a stick or limb, say one foot long, dia. from 1" to 4", season it and then saw off inch sections.

I've tried getting limbs in the months of November and January.

Please ask through your columns.

Respectfully, F. MILLER.

EARTHWORK PROBLEM.

(*See* ENGINEERING NEWS *of March 8th.*)

Special Correspondence Engineering News.

ROCHESTER, March 13, 1884.

EDITOR ENGINEERING NEWS.—1. Consider one of the side slope surfaces between the two stations at which the slope is different. Connect the two cut stakes by a straight line. Then the side slope at any section is straight from the point on that line to the edge of the roadbed.

Mathematically considered the slope surface may be formed by a straight line moving along the edge of the roadbed and the line joining the cut stakes, and also remaining parallel to the end sections. It is a hyperbolic parabaloid! and (see Davies Descriptive Geometry or some work on Warped Surfaces) may also be found by a straight line, first position in edge of roadbed; moving up the two lines of slope, with a velocity at each station proportioned to the length of slope at that station; its last position being that of the straight line joining the cut stakes.

The object of this is to show that through every point in this side slope surface a straight line may be drawn from one end of the volume considered to the other. Hence (see Trautwine, page 34) the Prismoidal Formula gives the correct volume.

2. As the outer edge of the cut is a straight line between the two slope stakes, at the mid-section, the side cut is their average cut at their average distance out.

On the right. Cut $= \frac{+6.42}{7.65}$ Ratio of slope $= 7.65 - \frac{1}{4}$ roadbed, 2.75 to 6.42 = .76 to 1.

On the left. Cut $= \frac{+0.935}{3.345}$ Ratio of slope $= 3.345 - 2.75$ to .935 = .64 to 1.

3 and 4. The area of mid-section and the volume are found as in any ordinary case.

The Prismoidal Formula will not give the *exact* volume if we make the slope at the mid-section ¾ to 1, that is, the average of the slopes at the stations. This surface would be formed by a line moving up the slopes 1 to 1 and ½ to 1, and remaining *parallel* with the roadbed. Outer edge of cut would be curved.

WILLIAM R. STORY.

Notes on the Construction and Equipment of Narrow-Gauge Railways.

(Concluded from page 124.)

Equipment.—But let us consider our road-bed and track as completed, ready for the running of regular trains, and mention some of the necessary equipment for doing business. Of first note is the rolling stock, consisting of locomotives, passenger coaches, baggage and express cars, box cars, flat and stock cars. The locomotives should, of course, be adapted to the service for which they are intended; those for the passenger service should have a larger wheel and quicker motion than those for freight; so of the other rolling stock, it should be adapted to the class of business required; but I leave the subject of rolling stock for some one better acquainted with it than I am, and mention briefly some of the equipments which more directly concerns the engineer, such as water stations, passenger and freight buildings, shops, engine-houses, turn-tables, etc.

About the first essential is the water supply for engines. During construction work, the engines may be supplied with water pumped by hand directly into the tender tank, or, better still, by a small steam pump, which may be shifted from point to point, or yet again by a steam syphon and hose carried with the engine, the hose of which can be dropped into any convenient ditch or pond of water by the roadside; in case of emergency, water may be bailed up with pails. All these processes are slow and tedious, and will not do for permanent use. Locations should be chosen at convenient points, at stations or regular stopping-places, not exceeding 20 miles apart—15 is better—and tanks of sufficient capacity put up. Tanks of 20,000 to 30,000 gallons capacity will answer where traffic is not very heavy, or even less would do, but small tanks are not advisable, as the supply is not as lasting, and in severe weather is more liable to freeze. The tanks should be erected upon a frame-work of posts of convenient height, so that the drop pipe will have a good sharp incline when water is being taken. For a tank of 20,000 gallons 12 posts 8 × 8 in size are sufficient; the foundation may be of stone or of piles capped with 8 × 8 for sills, the posts framed into them, and capped at right angles to the sills with 8 × 8 caps, on them rest the floor joists, and on the joints directly the bottom of the tank, the joists being cut away for the chine of the staves: a tank holding from 20,000 to 30,000 gallons, should be made of 3-inch staves and bottom. To make the tanks frost proof, all that is necessary is to put in a ceiling 18 inches below the top of the staves, and pack it with 18 inches of good sawdust, leaving the space between the top of the staves and roof, which should be perfectly tight, as a dead air space, also to pack it well around the supply, waste and delivery pipes and under the floor; in extreme cold weather it will of course freeze a little, but not enough to do any damage. There are ma y different methods of supplying the tanks with water; that most in use is by a small steam pump; wind power is also quite extensively used, and is considered quite economical, although my experience has been that it lacks in that respect and is not altogether reliable. Hot air engines are also somewhat used, and, I believe, are considered economical and reliable. Our company have had one in use at Vassar for the last six or eight months, and are well pleased with its performance thus far. Too much care cannot be taken to have good water and a supply that is permanent. Soft water from streams is considered the best; water containing minerals, especially lime and other substances that coat boilers, should be avoided.

Station buildings come next in importance to water-stations, if indeed any gradation in importance can be made; for successful and economical operating all are required. It may be supposed that during the process of construction, the location has been chosen and the grounds secured. Usually, during the first excitement of the enterprise and the rivalry of the different centres or villages in their effort to secure the road, a choice of location can usually be had, which should be made with reference to the convenience of access, and economy and convenience of laying out the sidings and arranging for the business of the company. It is well to secure ample room at first, for, after the grounds are once secured, it is strange how soon contiguous property appreciates in value, and often time it is impossible to obtain more room without buying at exorbitant prices. The station buildings should be of sufficient size to accommodate the business of the place. In small places, where one man does all the work, I think it advisable to unite the passenger and freight buildings in one, as it is more economical as well as convenient. For places of only a hundred or two of population, where business interests are not very great, I have found a building 16 × 40 feet in size to be ample.

A convenient one is built as follows: 16×40, with 12 foot walls, the interior divided in the middle, by an ordinary studded partition, making the freight room 16×20, and 16×20 for a waiting room and office; the office is made by running a lattice partition across the floor to ceiling, 6 feet from the end of the room. This lattice partition allows the waiting-room stove to do duty for the office as well,—another item of economy, as you will please bear in mind that I am speaking especially of the equipment of a narrow guage road, where cheapness and economy are a desideratum. In front of the office is a bay window, so that the agent or operator has full view of the track each way. In front of the building the platform should not be less than 12 feet wide; we build them one foot above the rail with a raised portion 8 feet wide in front of the freight room, and raise the freight room floor above the waiting room floor so as to be on a level with the floor of a box car; the platform across the end and rear of the freight room is level with its floor and descends again to the level of the waiting room by an easy incline. For a place of several hundred inhabitants, we build a station 20 × 70 feet in size, similar to the former with the addition of a baggage room; and in large places make them 20 × 100 feet or more. Where two waiting rooms are needed we build the office partially between the two, so as to give convenient access to both. We have found the system of passengers and freight in the same building to work satisfactorily, having in no case, except at terminal stations, any other arrangement, although in very large places it would not be desirable. During construction the engines are usually left standing out of doors with no cover whatever; sometimes a rough temporary shed or engine house is built; but it now becomes necessary to have permanent buildings for them. Such are usually built in a partially circular form, with stalls or divisions to accommodate one engine each. A suitable location is chosen, and a turntable put up, and. radiating from it as a center, the tracks enter each division of the engine house; underneath each track, inside the house is built a pit for convenience in working at the underside of the machinery. These houses are usually built of either brick or stone, although cheapness of construction being often demanded, wooden ones may be built with simply a frame work of 8″ × 8″ posts, with 8″ × 8″ caps, 2″ × 6″ studding 2″ × 10″ and 12″ joists; they should be sheeted around the outside, then papered with heavy building paper, then boarded and battened. Double doors in front of each division may be built on a light frame of 2″ × 4″ in the same way; a tar and gravel roof will do as well as any. At terminal stations and points where engines are kept for yard or other service a small building of sufficient size for the required service should be built, and may be located over an ordinary spur track in a convenient place. At headquarters in connection with the engine or round house, (as it is usually called from its partially circular form) should be the repair and machine shops, the size, equipment and capacity of which will depend on the number of engines to be kept in repair, and the amount of work to be done; the more complete they can be made as to machinery and appliances the more economically can the work be done, although of course due regard must be had to the means to do with. It is also necessary to have car repair shops and a place for storage of coaches when not in use. A supply depot is almost a necessity on a road of any importance. It is also necessary that a road should be furnished with the necessary sidings at different points along its line and yards at terminal and important points for the storage of cars, etc.

Cost—I am aware that I am already making this article too long, and am only touching upon a point here and there, so perhaps I had better close by giving an estimate of the various items of cost that are applicable to a narrow guage road, as very little of what I have already said will not apply to any guage of railroad. First the right of way must be secured, which through a farming and timbered country, like the lower peninsula of Michigan for example, will cost from $20 to $50 per acre, although usually from one-half to three-quarters can be secured as a donation. However, we will say an average of $40 per acre, which gives, for a right of way 4 rods wide, 8 acres or $320 per mile. Clearing through the average country above alluded can be done for $25 per acre, or $200 per mile, and grubbing will average perhaps $100 per mile, though in heavy timbered land it will cost very much more. A fair price for ordinary earthwork is 25 cents per yard, and at 5,000 yards per mile, (although on the P. H. & N. W. Ry., of over 200 miles, the average has been less than 4,000 yards per mile), we shall have for earthwork $1,250. Bridges, if not too expensive, may be figured $200 per mile and culverts at $100. This will give for right of way and road bed as follows:

Right of way	$320
Clearing	200
Grubbing	100
Earthwork	1,250
Bridges and culverts	300
Total	$2,170

Ties will cost say 20 cents, although the average price paid for more than half a million ties used by the P. H. & N. W. Ry., has been but little more than 10 cents.

2,640 ties per mile at 20c	$528.00
Rails (steel), 35lbs. per yard, 55 tons per mile, at $50 per ton	2,750.00
Fish plates, 532 pairs, weighing 8 lbs. per pair, at 3c. lb	127.00
1,408 bolts, ½ lb. each, at 4c	28.10
Spikes, 27 kegs per mile, 150 lbs. per keg, at 3c. lb, (now considerably less)	121.50
Track laying per mile	200.00
Ballasting, 35c. yd., 1,100 yds. per mile	385.00
Making per mile	$4,139.74
To which we must add about 5 per cent minimum for siding, etc.	206.98
Total per mile	$4,346.72

We will perhaps arrive at a better result for equipment by considering the amount needed for 100 miles of road. Let us say,

8 locomotives, from 14 to 20 tons @ $8,000 each	$64,000
6 first-class coaches @ $3,000 each	18,000
6 second-class coaches @ $2,300 each	13,800
4 baggage and express cars @ $1,700 each	6,800
150 box cars @ $325	48,750
10 stock cars @ $350	3,500
50 flat cars @ $225	11,250
Hand-cars	900
Total for rolling stock	$167,000

or $1,670 per mile.

Water stations at terminal stations, and 4 intermediate on the 100 miles will cost $700 each	$4,200
For station buildings we will say 12—6 of the smaller size mentioned, which, with platform and outbuilding complete, will cost $600 each	3,600
Four, 20′ × 70′ in size @ $1,000 each	4,000
Two, 20′ × 100′ in size @ $1,300	2,600
Larger passenger and freight buildings at headquarters costing	15,000
Engine-house of eight stalls at headquarters	7,000
Small engine-house at other end of line	500
Two turn-tables @ $600 each	1,200
Machine shops and machinery	10,000
Car repair shops	6,000
Coach house	1,000
Telegraph line	5,000
Total	$55,100

or $551 per mile. Making a summary as follows:

Right of way, road-bed, etc., per mile	$2,170.00
Ties, iron, track-laying, ballasting, etc.	4,346.72
Rolling stock equipment	1,670.00
Building	551.00
Fencing	600.00
Making a total per mile of	$9,337.72

to which may be added engineering and contingent expenses, which will make in round numbers at least $9,500 per mile.

DISCUSSION.

MR. G. M. BROWN: I consider hemlock the best timber for ties, not especially for its durability, but for its property of holding spikes. In laying ties of different kinds of timber, I would place each kind, hardwood and soft, by itself. The ties on the F. & P. M. R. R., are 8 feet long and 8 inches wide; their average cost on our road in 1883 was 18 cents.

MR. W. B. SEARS: The greatest enemy the railroad engineer encounters is the swamp. In this State swamps are frequently found, that, so far as firm ground is concerned, are nearly bottomless. Small ones will absorb acres of timber and thousands upon thousands of yards of earth, and even then the grade that is obtained cannot be held. They were well called "sink-holes." In one instance I have driven piles 160 feet. I have had success in putting on a layer of trees before theearth.

M. J. J. WATKINS: In the older part of the State ties cost from 30 to 40 cents each.

MR. A. L. REED: As to making embankments narrow and afterwards widening them, this plan requires more earth and is in danger of slips. Our practice is to build full width before the rails are laid. In regard to ties, I gave figures of actual cost for ties seven feet long, six inches face. I think cedar the more valuable.

A PEERLESS water guage has been placed in the office of the Superintendent of Water-Works, Minneapolis. The instrument is connected with the pump house, and registers the pressure with a circular diagram register, showing the pressure variations.

IN the Massachusetts Legislature the Haverhill Aqueduct Co.; the towns of Dalton, Woburn, Concord, and the Athol Water Co, are applying for power to increase their water supply; the Bradford Water Co. is applying for articles of incorporation with capital not exceeding $100,000.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E. : M. INST. C. E.

(*Continued from page* 130)

DCVII. BERTHIER, QUE.

Berthier, Quebec, in lat. 46° 5′ N. long. 73° 10′ W. on the St. Lawrence River is in a fertile district, and has mineral springs of some repute. It was incoporated a city in 1876.

Water works we e built in 1879 by a private company after plans of J. U. Foucher, taking supply from the River St. Lawrence. The water is filtered through broken stone, wood charcoal, and gravel, and passes through a 12-inch cast-iron pipe to a stone pump well with iron bottom, whence it is lifted 45 feet by two steam pumps of 6 in. diameter, and 18 in. stroke, built by G. A. Pont Briond, of Sorel, into a wooden tank 38 feet in diameter and 13 feet high, on a brick foundation, 40 feet above the general level of the city. The pumps can also furnish a fire pressure of 100 lbs. Distribution is by 3 miles of cast-iron pipe of 8 to 2 in. diameter, with 12 fire hydrants, 8 gates, and 400 taps. The city pays $200 per year for hydrant service. Service pipes are of lead.

The population in 1880 was 1,620. The daily consumption is not given.

The works have cost $20,000. The expenses in 1883 were $800 and the receipts $2,200.

The works are owned by J. U. Foucher, and operated by him under a contract with the city for 50 years.

DCVIII. SAN BUENAVENTURA, CAL.

San Buenaventura, California, in lat. 34° 20′ N. long. 119° 20′ W., is on the Pacific coast at the mouth of the San Buenaventura River. It is a favorite place of resort for invalids on account of its fine climate and hot springs. It was settled by Spanish Missionaries in 1780 and incorporated a village in 1870.

Water-works were built by a private company in 1872, after plans of E. F. Hare, taking the supply from the San Buenaventura River, which drains the Southern slope of the Santa Inez mountain range. An impounding reservoir 200 by 150 feet retains the water 175 feet above and 2¼ miles distant from the town, to which it is conveyed in a 10 in. riveted wrought iron pipe. Distribution is by 5½ miles of wrought iron pipes, asphalted, of 10 1½ inch diameter, the larger sizes riveted and the smaller welded. There are 6 fire hydrants. The number of taps is not given. The town does not pay for fire protection. Service pipes are of galvanized iron.

The population in 1883 was 1,500. The consumption is not known. The capital stock of the Co. is $75,000. The works have cost $45,500. The expenses in 1883 were $1,424.98, and the receipts $4,553.25. A. E. Brady is President, and E. P. Foster, Secretary and Superintendent.

NOTES.

There are a number of towns which are known to have water-works, but from which no response can be obtained, notwithstanding the superintendents having in their hands the blanks and post-paid envelopes. In addition to those named in our columns a couple of weeks ago, the following places have not yet responded, and any information regarding their water-works will be gladly received by J. J. R. Croes, 63 Bleecker street, New York City—viz: Lake View, Ill.; West Bay City, Mich.; Athens, Ga.; Plymouth, Pa., Turner's Falls, Mass.; Ishpeming, Mich.; Rockville, Conn.; Tamaqua, Penn.; Gloucester, N. J.; Silver Cliffs, Colo., and Claremont, N. H. All of these cities have over 5,000 inhabitants, and there ought to be some one in each of them who can give the desired information.

WATER.

BATH, Me. is to have water-works.

MR. J. N. SCATCHARD has resigned his office of Water Commissioner of Buffalo, N. Y., on account of ill health

THE town of Cornwall, Canada, is now stirring in the matter of establishing waterworks. A deputation, consisting of the mayor and council visited Ottawa recently to obtain legislative sanction to use power from the Cornwall Canal for pumping purposes.

AT a meeting of the Salem, Mass. aldermen last week a communication from the Water Board, asking for immediate action upon the matter of an additional water main via Danversport, was referred to the Committee on Water Works to meet with the Water Board, and to report plans and estimates.

SOME time ago we noticed an account of excavating a bluff in Minnesota by hydraulic action. The first attempt at this process in the East has just been successfully made at Richmond, Va., U. S. by Assistant Engineer C. P. E. Burgwyn under the direction of Lt.-Col. Wm. P. Craighill. The bluff on one side of Dutch Gap was tumbled into the strong tidal current by being undermined by hydraulic pressure, and the work of days accomplished in a few hours. An account, at some length, of the operation is given in the Richmond *Despatch* of the 13th.

THE towns of Ware and Goffstown, N. H., have voted to raise $2,500 on certain conditions toward the reservoir project in Deering, at their annual meeting. If carried out, the benefit to those towns for manufacturing purposes will be very large.

The principal article in the Nahant town warrant is to see what action the town will take with reference to issuing bonds for $65,000, to run twenty years, to defray the cost of the introduction of water.

THE Morristown, N. J. Aqueduct Company is laying two to three miles of ten-inch pipe to secure an additional supply of water for an extended future service.

The pipe is cast by the Mellert Foundry and Machine Co., Reading, Pa. Geo. W. Howell is the aqueduct company's engineer.

During 1883 the city of Lewiston, Me., used 467,353,800 gallons of water against 464,494,100 gallons for 1882. During the past year forty meters were put in by the Water Board and resulted in largely checking the waste of water by consumers.

DEAN BROS. Steam Pump Works have recently received orders for their Independent Air Pump and Condenser from the Logansport (Ind.) Electric Light Co., Clinton (Iowa) Water Works, Yaeger Mill Co., Kane, Ill., and Brush Electric Light Co., Indianapolis. Dean Bros. are getting out patterns for a new line of Duplex Pumps.

THE contract for valves needed for Buffalo, N. Y. Water Works during 1884, ranging from 4 to 36 inches in size was awarded on the 13th to the Eddy Valve Co., of Waterford, N. Y.

WE are indebted to the courtesy of Edmund B. Weston, M. Am. Soc., C. E., principal assistant engineer of Providence, R. I., with special charge of the Water Department, for a pamphlet giving a general description of the Providence Water Works, a document rendered necessary as a reply to the numerous inquiries concerning them. It can probably be obtained by applying to Mr. Weston.

THE water of the Penobscot at Bangor, Me., has lately been analyzed by Prof. Marker of Boston and Prof. Robinson of Brunswick, each of whom has pronounced it suitable for drinking and domestic purposes. The analysis was made on account of charges made several months ago that the water had become impure and unfit for use. The reports show no material change in the condition of the water since 1873, before the building of the dam.

RED BANK, N. J., March 20.—The Town Commissioners have ordered that a special election be held on next Monday to decide whether the town shall be bonded for the construction of water works, under the provisions of the Water bill recently passed by the Legislature. At an election held a year ago a large majority voted in favor of building water works by bonding the town, but the election was illegal. Within four years nearly $1,000,000 worth of property has been destroyed here by incendry fires, and the insurance companies have cancelled many policies.

MAYOR'S OFFICE, CITY HALL,
PEORIA, ILL., FEB. 1, 1884.

Dean Brothers Steam Pump Works, Indianapolis, Ind.:

GENTLEMEN—I take pleasure in certifying to the efficiency and reliability of the pumping-engines which you furnished for the Water-Works of this city. Your engines were put to work in the year 1875, during my first term as Mayor of this city, since which time they have constantly supplied this city with water. Our system of supply is "direct pressure." There being no reservoir, the engines are required to work night and day to maintain the supply. During nearly nine years of service your engines have given entire satisfaction, having never failed in a single instance. These engines furnished fire protection to the city, and the pressure required at the Water-Works is 150 lbs. per square inch, and in some instances the pressure is run up to 180 lbs. The engines have always done the work economically, have never broken down, and are now, after nine years' service, in first class condition. Respectfully yours,

JOHN WARNER, Mayor.

MORE than 1,300 feet of the Lynn Water Works tunnel are completed, and it is believed that the whole will be done June 1st.

A TANK 30 feet in diameter and 76 feet high, for water-works purposes at Newton, Kan., and two 70-horsepower boilers, for same parties, are in course of construction at the work of Messrs. E. E. Palmer & Son, of Kansas City, Mo.

ON the 11th, the Board of Water Commissioners of St. Paul, Minn., presented a communication requesting an appropriation of $600,000 to complete the water works system, which was favorably considered and referred.

A resolution, instructing the City Council to issue $100,000 of St. Paul Water Bonds, in denominations of $1000 each, bearing date of April 1, 1884, at five per cent. per annum, and redeemable April 1, 1913, for the purpose of constructing new Water Works. Passed.

A resolution requesting that $500,000 of bonds of the City of St. Paul, of $1000 each, at five per cent. per annum, payable semi annually and redeemable in 1905, twenty-five years from date, be placed in the City Treasury for the purpose of enlarging the Water Works in St. Paul. Passed.

SUITS GROWING OUT OF THE BLACKSTONE RIVER DISASTER.—WORCESTER, MASS., March 7.—In the cases against the city for damages by pumping water Tatnuck Brook at the time the city reservoir gave away in 1876, verdicts were to-day rendered in favor of the mill owners in sums ranging from $1 to $355.22. The writs were brought by manufacturers from this city to tide-water on the Blackstone River. The verdict is regarded as virtually in favor of the city, tho point made that two-thirds of the water was returned to the stream being sustained.

THE Salem Mass. Water Board, with the Committee on Water Works, held an important meeting recently. Tuesday's shutting off of the gate in the principal water main, leaving the city to derive its water supply from the six-inch water pipe connection round through Cabot street in Beverly, demonstrated the fact very forcibly that this means of supplying the city was wholly inadequate to the demand made upon it, and that if any leak of serious magnitude in the principal twenty-inch main should occur the city would be entirely without water other than from the old pump wells and what little could be spared from Peabody in the old aqueduct pipes. There is not a reservoir of large dimensions in the city, and the old-fashioned underground fire department cisterns could be exhausted in a very few hours, even if the water standing in them was found to be fit to drink. The gravity of the matter has hardly been realized. It was voted to send a communication to the City Council at its next meeting to ask immediate attention to the condition of the city and the necessity of an additional water main for a reserve supply in case of sudden emergency. A letter from the Hon. James J. H. Gregory of Marblehead, asking if the Salem Water Board had any proposition to make with reference to supplying water to Marblehead, was read, and it was voted to send back an answer that the board had none.—*Boston Journal.*

THE WATER METER QUESTION.—The opposition to the proposed act establishing an inspection of water meters by the State has opened the eyes of the members of the Legislature to the necessity of some stringent regulation in regard to water meters. It is not the people of Boston who are to be exclusively protected, but every resident of any town where water is introduced through pipes. It will be very easy for a few men in a small town to form a ring, and by securing the co-operation of the officials of the Water Board go through the form of testing a meter which they own, and then, taking from the pockets of the people thousands of dollars, laugh in their sleeves at what "fools these mortals be." The State is asked to establish some protection against such schemes. Six months ago we urged that the test applied to the Tremont meter was insufficient, and we suggested that an open investigation, conducted by scientific and independent men, should be established. We are happy to see that the *Herald* is waking up to this proposition. It now says:

"In the course of the testimony before the committee, Mr. Moody Merrill, who is interested in the Tremont water meter, stated that if the committee had a disinterested expert they would like to employ to make a test, the Tremont Company would pay the expense of such a test. This is a fair enough offer, but of course is not likely to be, or could, in the nature of things, be accepted by a legislative committee; but, if Mr. Merrill means what he said, there is a practical way of settling all disputes in regard to the superiority of his meter. It is that a public test be given of the various water meters by disinterested persons appointed by the city authorities of some one of the most important cities of New England—to be agreed upon by parties interested or to be indicated by some disinterested party named by them—some city whose officers are free from the scandal of jobbery, etc. That each of the companies contribute a meter of its own make of a size agreed upon—three-quarter inch or inch, as the case may be—and contribute an equal share to the expense of the competition. Some such test might be made, and if the Tremont meter is the best, it will assert its superiority there, as it is said to have done in the secret test made in Boston. A law regulating the adoption of water meters by previous public trial seems to be called for, however, in any event."

In any event, as the *Herald* says, give us a law which will prevent jobbery that in the end will cost the citizens of Massachusetts millions of dollars. Why any member of the Water Board could oppose such a law is a mystery.—*Boston Journal.*

NEWS OF THE WEEK.

Railroads, Bridges and Canals.

THE Portland Locomotive Works have turned out an engine for the Northern Pacific which is on exhibition at the Eastern Railroad engine house here. The new locomotive has a novelty in the Joy valve motion, the first used in this country; it does away entirely with eccentric links; the valve works from connecting rods, and has Butterfield ash pan.

THE St. Louis bridge and tunnel last year cleared a surplus of $121,062. The gross earnings were $1,413,617.

TEN thousand men and four thousand teams are ready to begin work on the Winona, Alma & Northern Railroad as soon as spring opens.

THE certificate of incorporation of the Rapid Steamship Company was filed on the 18th; capital $250,000. The corporators are John Roach, John W. Handreau, Alexander Sawyer and Miers Corvell. The company intends to supply their vessels with an auxiliary screw propelling power, in addition to that in ordinary use, thereby securing a greatly increased speed.

THE construction of the new Staten Island Rapid Transit Railway along the shore of the Narrows from Clifton to New Brighton was begun on Monday, when a party of surveyors marked out the grades and broke ground for the road bed. Next week a large force of men will be put to work by the contractors.

MASSILLON, O., March 15.—The contract for building the extension of the Wheeling and Lake Erie Railroad from Valley Junction to Bowerstown, the crossing of the Pan Handle, was awarded to-day to W. F. Stanley, a well-known contractor. The distance is twenty miles, and is to be completed by the 15th of June next.

THE Cleveland and Western Railroad Com has been incorporated. Headquarters, Cleveland, O. It is a local enterprise. The incorporators are Messrs. E. W Laird, Charles E. Farrell, T. M. Irvine, A. K. Robinson, A. J. Wenham, and A. J. Marvin.

A BILL authorizing the Grand Trunk Railway Company to raise capital to double track its line from Toronto to Montreal passed the House of Commons Committee on Railways to-day. Manager Hickson of the company says that the money can be readily raised, and that work will begin at once. Grades will be lessened and the whole line put in first class condition at a cost of about $8,000,000. These improvements are made necessary in order to compete successfully with that portion of the Canadian Pacific's line which is parallel with the Grand Trunk.

CITY OF MEXICO, MEXICO, March 15—The first through train over the Mexican Central Railroad left here this morning, having on board A. J. Cassatt, of Philadelphia, General Manager Robinson, and a number of their friends. The train was composed of private cars. The road will be opened to freight and limited passenger traffic on April 1. Regular express trains with Pullman cars attached will begin running on May 1.

TOPEKA, Kas., Mar. 14.—Articles of incorporation were filed here to-day by the Salina, Lincoln & Fremont Railroad, the object being to survey, locate, construct, operate and maintain a line of standard gage railroad from the counties of Salina, Ottawa, Cloud, Clay and Washington, to intersect the State line between Kansas and Nebraska on the north line of Washington County. The capital stock of the company is placed at $1,000,000, and the general offices of the company are to be placed at Washington, Washington County. The directors for the first year are William Kalhoefer, Hanover; W. H. Collins and Thomas Goody, Washington; C. C. Furnell, Clifton; D. M. Gillespie, Carmel; H. B. Baker and O. P. Hamilton, Salina; S. C. Smith, Beatrice, Neb.; John W. Burke, Lincoln, Neb.; W. H. Dickinson, Wahoo, Neb.; G. W. E. Dorsey, Fremont, Neb.

Since January, 1882, fifty-six new railroad companies in the State of Kansas have filed articles of incorporation with the Secretary of State.

SOME thirteen bridge men awaited the opening of the bids for the Good Thunder Bridge to-day and twelve of them took the swearing train this evening.

The award for the building of the wrought iron Pratt truss bridge, over the Blue Earth, at Good Thunder, this county, was to-day made to P. E. Lane, bridge builder, No. 177 La Salle street, Chicago, at $6,100. It rests upon piers already built, and is to be a single span of 194 feet.—Mankato, Minn. paper, 10th.

BRIDGES DESTROYED.—The Cleveland *Iron Trade Review* published on the 15th reports from twenty-one railroads and thirty-four counties, between Pittsburg and Cairo, showing the number of bridges destroyed in the Ohio Valley by the recent floods. The railroads report the loss of two iron and three wooden bridges, the aggregate lehgth of the former being 635 feet and of the latter 604 feet, and the estimated cost of replacing them $42,000. The counties report the loss of three iron and forty-seven wooden bridges; total length of the former 304 feet and of the latter 5,094 feet. Cost of replacing, $168,000. Grand total of the bridges destroyed, fifty-five; length, 7,437 feet; estimated cost of replacing them, $210,000.

OTTAWA, Ill., March 15.—The proposal to build a $50,000 bridge across the Illinois River within the city limits of Ottawa, to which t e county is asked to subscribe one-half under the laws, has developed a question which will require a decision from the Supreme Court. After hearing arguments the Circuit Court to-day issued a writ of mandamus to compel the County Board to make such appropriation, whereupon the board, being in session, took an immediate appeal to the Supreme Court. All admit the necessity of a new bridge.

ALBANY, N. Y., March 19.—A final hearing on the Broadway Arcade Railroad bill was had this evening before the joint Railroad Committees of the two houses. Alvah P. Mason, E. S. Jaffray, S. V. R. Cruger, and one or two other gentlemen representing the Trinity Church Corporation and other property owners on Broadway appeared in opposition to the bill Their opposition was directed to the practicability of the scheme both in an engineering point of view and financially, and to the great injury which they believed it would inflict on Broadway property-owners, and the delay and inconvenience it would cause to traffic and travel on the street. A large part of their arguments displayed such ignorance of the details of the scheme they were opposing that they had very little effect on the committee, and were easily refuted by a few plain facts stated by Mr. McAlpine, the engineer, and by Mr. Post, the architect.

THE Burlington Railroad has been quietly engaged in arranging for a new line from St. Louis to St. Paul, the details of which have only lately become known. To avoid suspicion of what was contemplated, and to prevent any move to forestal the end in view, a route between those points was surveyed, and three distinct charters were obtained and organizations formed. These were seemingly independent and harmless local lines, but they have in view the coming together for one common purpose, and that is the construction of an air-line railroad to connect with the Burlington and the Rockford and Rock Island, that will give the shortest route for travel and traffic between the main line of the Northern Pacific and St. Paul, St. Louis and Chicago.

This will make the distance between St. Paul and St. Louis sixty miles less than by any other rail route. The innocent-looking little lines will be consolidated in one, and become a part of the Burlington system. Construction has been begun, and only a few minor details remain incomplete.—*Philadelphia Press.*

WASHINGTON, Mar. 12.—The bill reported by the House Committee on Pacific railroads to incorporate the Spokane Falls & Cœur d'Alene Railroad Company to construct a railroad to the new gold region in Idaho Territory, designates K. J. Browne, A. M. Cannon, A. L. Davis, O. F. Weed, H. L. Cummings, W. H. Armstrong and such other persons as may be associated with them as incorporators of the company. The road will extend from Spokane Falls, Wyoming Territory, by way of Fort Cœur d'Alene to an intersection with the Northern Pacific or Utah Northern Railroad in western Montana, and will have branch lines from the main line in Idaho Territory up each of the following rivers: Cœur d'Alene, St. Mary's and St. Joseph River to near the sources of the same. A railroad and telegraph line will also be constructed from Spokane Falls to Moscow, in Idaho. The company is authorized to construct and operate on Lake Cœur d'Alene and Spokane, St. Mary and Cœur d'Alene Rivers, a line of steamboats, tug-boats, tow-boats, barges and other water craft.

The Board of Incorporators is required to meet in Spokane Falls within ninety days from the passage of the act to open books of subscription for stock. The company is given power to consolidate with any railroad company or companies, and is granted all rights and privileges conferred upon railroad companies having right of way through public lands of the United States.

RECEIVER Ashbel Green has given notice that the North River Construction Company will go into liquidation and that the books have been closed permanently.

Streets, Drainage, Sewerage, Etc.

AT the town meeting in Waltham, Mass., held Tuesday evening, it was voted to adopt the recommendation of the Board of Health in reference to appointing a committee to consider the question of sewerage and drainage for the town, and the town selected as this committee the members of the Board of Health, and Messrs. E. T. Luce, E. P. Smith, D. E. Getchell and Ambrose Webster. They were authorized to investigate and report in reference to a system of sewerage, and to employ sanitary engineers fo assist in the work.

THE bill to allow the city of Petersburg to adopt a system of sewerage has passed the Virginia Legislature.

THE rapid growth of the city within the last few years has outrun to a great extent the sewerage system, leaving certain portions poorly supplied. Superintendent Cheney, of the Sewerage Department, asked for an appropriation of $325,000, but was cut down by the Finance Committee to $225,000, and these figures may be reduced still lower by the Council.

One of the important sewers to be constructed during the coming year is the Kedzie avenue sewer to run from Twenty-first street to Kinzie street, for which the Finance Committee allowed $45,000. The Armitage avenue system, which when completed will extend from the North Branch to city limits, a distance of three and one-half miles, will also be commenced, and will cost when finished $200,000. The Superintendent asked for $80,000 to begin the first 3,000 feet, but was cut down to $45,000. This is to be a large system, and will drain the northwestern portion of the city, which has grown out beyond all existing sewers. It will run from the North Branch to Western avenue, south to Hirsch street, west to California avenue, south to Augusta, and west to the city limits.

The Finance Committee has allowed $9,000 for the Thirty-fifth street sewer, which will run from Ashland avenue to Wood street, and $150,000 has been recommended for numerous small extensions. The Fifth, Sixth, Seventh, Twelfth, Thirteen and Fourteenth Wards require sewerage more than any other portions of the city, as they have less in proportion to miles of sewer. Two miles of sewer will also be added between Western avenue and the city limits.—*Chicago Tribune.*

STREET PAVING IN E. SAGINAW, MICH.—We are indebted to the courtesy of Mr. E. F. Guild, of E. Saginaw, for the summary of a large amount of paving let in that city on the 11th ult. There is too much of it to publish in full, but we herewith give the range of prices of the work. On Jefferson street, Robert Davidson was awarded a contract for grading at $1.50; excavation, .25; cedar block paving, .64 per sq. yard; stone curb .48 (80ft. culverts at .50); board foundation, $11 per m.; pine culverts $1 each; total for 40 rods lineal, $2,748.26. On the same street on another section Eugene Robinson was paid .47 and .37 per sq. yd. for cobblestone pavement. On Millard street, Robert Davidson got the contract at the following prices: Grading, $1.75; excavation, .30; cedar block pavement, .64; stone curb, .50; cobblestone, .96; pine foundation at $11 per m.; culvert covers at $8. The highest paid for grading was $2.00, and the highest for cedar blocks .70. The above figures show the range of bids. Total contracts let, $38,632.

Contracting Miscellany.

ABOUT 10 years ago the town of Westchester, N. Y. paid $110,000 as its share in the construction of the Eastern Boulevard. The contractors for Unionport Bridge, Paulding & Co., of Cold Spring, claimed that a balance of $10,000 was due them. They sued the Commissioners and got judgment, but were unable to collect it. They have now caused a bill to be introduced in the Legislature providing that the town shall be bonded to pay the claim, which, with interest, amounts to about $16,000. The people of Westchester are up in arms about it, and say that they paid the Commissioners who had charge of the work, and that they should not be made to pay again.

SAN FRANCISCO, Cal.—March 19.—The breaking of a levee at Roberts Island, near Stockton, Cal., last night, destroyed 27,000 acres of wheat, valued at $500,000.

COURT HOUSE, ETC., COLUMBUS, OHIO.

Synopsis of bids opened March 17, for furnishing and setting stone work of superstructure received under advertisement dated February 23, 1884:

STONE WORK.

W. Fish & Sons, $28,885.
W. B. Collingwood, $33,885.
Smith, Sargent & Co., $29,550.
Smith, Sargent & Co., $33,000.
James Westwater, $37,993.
Wm. S. Burns & Co., $38,932.
Andrew Doll, Jr. $39,266.
E. R. Brainard & Co., $39,900.
Wittenmeir Bros., $40,000.
M. A. McGowan, $42,140.
Rees, Evans, $42,567.
Jacob Vehmeyer, $43,500.
E. J. and F. Dobbling, $47,529.
Peter G. Straub & Co., $44,750, $43,430.

BRICK WORK.

Blaisdell & Co., $12,973.
Rees Evans, $13,793.
James Westwater, $14,800.
Simeon C. Kane, $14,838.
M. A. McGowan, $15,400.
Jacob Vehmeyer, $16,750.
Smith, Sargent & Co., $17,321.
Adam Schneider, $17,777.
Peter G. Straub & Co., $17,740.

JOINER'S WORK AND WOOD FLOORING, MONTGOMERY, ALA.

Bids opened March 19, under advertisement dated February 27, 1884:
Thorn & Gorrie, $14,700. and $15,200.
Joseph Thomas & Son, $15,000 and $15,790.
W. M. Nolls, $15,742.11.

THE bid of Jones & Benner for work on the Public Buildings in Philadelphia was $81,943, instead of $181,943 as stated in last issue.

THE Senate passed a number of bills authorizing the construction of Public Buildings, not to exceed for site and building, the following amounts:
Carson City, Nevada $100,000.
Waco, Texas, $100,000.
San Antonio, Texas, $200,000.
La Crosse, Wisconsin, $100,000.
San Francisco, $400,000.
New Albany, Indiana, $100,000.
Winona, Minnesota, $100,000.
Oshkosh, Wisconsin, $100,000.
Fort Smith, Arkansas, $100,000.
Nebraska City, Nebraska, $75,000.
Pueblo, Colorado, $200,000.
Fort Scott, Kansas, $100,000.

THE Elephant Building Company has filed articles of incorporation to the County Clerk's office, Brooklyn. The capi al stock is $250,000, and the incorporators are C. W. Douglass, James V. Lafferty, George W. Allen, and George Ridgewood. The company proposes to put up at Coney Island a huge hotel in the form of an elephant.

BELMONT Co., Ohio, is authorized to borrow $100,000, and to issue bonds to build a court house and jail.

LIGHT INFANTRY ARMORY BUILDING.

THE bids for erecting the new armory building for the Washington Light Infantry were opened February 28 at the office of the architects, Messrs. Gray & Page. The bids were as follows:
John Henderson, $98,500.
F. Pilling, $103,750.
Langley & Gettinger, 102,705.
McCarty, $97,750.
Kenderdine & Paret, $94,670.
George Corbett, $98,500.
Parry, $91,596.
Thomas, $99,600.
Bright & Humphrey, $103,849.
M. M. Magruder, $102,492.
J. Downing, $99,480.
Morrison, $106,474.
Howlett, $85,050.
Holtzclaw, $109,936.
Downing Bros. $103.467.

CUSTOM HOUSE AT BUFFALO, N. Y.

THE following is a synopsis of bids for labor and materials and setting stone for the custom house, etc., extension at Buffalo, N. Y.:
W. D. Collingwood, $12,990.
Jared H. Tilden, $17,641.
John Druar, $19,834.
M. A. McGowan, $21,010.
Rumrill & Rupp, $26,666.
M. McNamara, $50,000.
The bid of W. D. Collingwood, $12,990, the lowest has been accepted.

IRON AND SLATE WORK AT MEMPHIS, TENN.

Synopsis of bids for iron and slate work of stairways for the custom house, etc., at Memphis, Tenn.:
McHose & Lyon, $6,050.
Poulson & Eger, $6.850.
Snead & Co., Iron Works, $7,620.
Chenu & Hewlett, $7,910.
Bartlett, Hayward & Co., 8,300.
Haugh, Ketcham & Co., $8,715.24
Phœnix Iron Works, Trenton, $9,700.
The Merz Architectural Iron Works, $10,600.
Manly & Cooper Manufacturing Company. $13,995.
Wm. H. Jackson, $9,300.
The bid of McHose & Lyon $6,050, the lowest has been accepted.

BIDS FOR IRON GALLERIES AND STAIRS AT CINCINNATI, OHIO.

The following is a synopsis of bids for iron galleries and stairs for the custom-house and post office at Cincinnati, Ohio. (Advertisement dated February 20, 1884):
Snead & Co. Iron Works, $5,512; additional stair, $295; aggregate, $5,807.
McHose & Lyon, $6,000; additional stair, $230; aggregate, $6,230.
Haugh, Ketcham & Co., $6,072.45; additional stair, $244.82; aggregate, $6,317.27.
Joseph Hall & Co., $7,630; additional stair, $250; aggregate, $7,880.
M. Clements, $7,644; additional stair; $240; aggregate, $7,884.
The contract will be awarded to the lowest bidder.

STONEWORK FOR QUINCY, ILL.

The following is a synopsis of bids for stone work for post office, court house, etc., at Quincy Ill.:
Indiana Oolitic Limestone Company, $37,997, Oolitic limestone, this year if contract made at once.
W. D. Collingwood, $42,345, Bedford, ten months.
Blatz & Krebs, $50,572, Bedford, 225 days.
Larkeworthy & Menke, $54,350, Bedford, Quincy steps, $63,500, Quincy, Bedford steps.
Scott Weber, $54,464, Bedford, September, 1884.
M. A. McGowan, $55,101.25, Quincy limestone, twenty months; $66,084.18, Illinois limestone, twenty months.
Smith, Sargent & Co., $55,737, Lemont, fifteen months; $60,131, Bedford, fifteen months.
E. R. Brainard, $52,495,22, Indiana limestone, October, 1885; $58,608.82, Illinois limestone, October, 1885.
Hughes & Dugan, $63,690, Bedford, or Warrensburg, eighteen months.
James A. McGonigle, $67,635, Bedford buff, eighteen months.
Sales, Burns & Co., $79,000, Bedford, 450 days.
Thomas Osborne, $83,000, eight months.
The Young & Farrell Diamond Stone and Sawing Company, $104,239, Lemont, December 1, 1884; $109,239, Indiana limestone, December 1, 1884.
The bid of the Indiana Oolitic Limestone Company ($37,997) the lowest has been accepted.

NEW BUILDINGS PROPOSED.—The House Committee on Public Buildings agreed to report favorably bills making appropriations for new buildings at Wilmington, Del., to cost $150,000; at Tyler, Tex., to cost $75,000; at Waco, Texas, to cost $100,000; at Sacremento, Cal., to cost $100,000 and Jackson, Mich., to cost $75,000. It was agreed to ask the Committee on Appropriations to make an appropriation of $50,000 for the building at Memphis, Tenn.

THE St. Paul Foundry and Manufacturing Company has received the contract for the iron furnishings of the Dakota penitentiary.

J. LEWIS LYNN, has contracted with the city of Erie, Pa., to do a large amount of dredging in the slips at the rate of $7.50 per hour. Government employes are at work on the ice east of the piers drilling holes through the sand to the rock beneath at intervals of 1,000 feet. This work is being done with a view of building an extension to the piers on rock foundation. The sand is sixty feet deep. The drill is made of gas pipe with a sharp point, and this is perforated near the point. Water is forced down through the drill thereby keeping the sand from wedging in ahead of the drill and giving it free field. Assistant Harbor Master Kingsley is doing the work, assisted by Captain Parsons, a well-known lake engineer.

SEALED proposals will be received at the office of the Board of Improvements, Cleveland, O., until April 3, 1884, for dredging and removing bars and other obstructions from the channel of the Cuyahoga River, from the Lake Shore & Michigan Southern Railroad bridge, near Front Street, to the new canal transfer dock; also the Old River Bed, for the season ending December 31, 1884; also at the same office and the same date, sealed proposals will be received for grading, draining and paving with Medina dressed block sandstone, Wilson avenue from Euclid to Woodland avenue.

COST OF THE U. S. PUBLIC BUILDINGS.

The following is an official statement of the cost of the principal public buildings in the District of Columbia on June 30, 1883, exclusive of the grounds:

Winders and adjacent building	$245,000
Department of Justice	197,779
Bureau of Engraving and Printing	366,930
Medical Museum	88,000
Post-Office Department	2,151,500
Government Printing Office	296,000
United States Marine Barracks	339,637
United States Naval Hospital	116,035
President's House and Conservatory	735,580
President's Stable	28,500
United States Treasury Building	7,158,454
State, War and Navy Buildings	7,628,925
Agricultural buildings, hot-houses, etc	501,825
Smithsonian Institute	492,651
National Museum	250,000
Washington Monument	794,163
United States Observatory	255,264
Arsenal Buildings	270,324
Patent Office Building	3,245,778
City Hall	275,152
Pension Office Building	137,000
New Jail	525,550
United States Navy Yard	3,615,808
United States Capitol	15,599,656
United States Aqueduct	3,847,547
United States Military Asylum	350,000
Columbian Institute for Deaf and Dumb	751,000
Government Hospital for the Insane	1,513,112
Total	$52,977,170

IRON, METAL AND COAL MARKETS.

PHILADELPHIA, Mar. 20, 1884.

The Iron Trade has developed considerable quiet strength, a fact shown by the refusal of makers to accept the offers which have been made for both crude and finished Iron. The decline in crude Iron stocks is such as to enable holders of standard brands to get their price for all they have to offer. Standard forge is selling at $18@$18.50, the majority at the latter figure, for tidewater delivery. Very best foundry $21.50, but most foundry can be had at $20.25. Some inquiries have been made for large lots, and only the refusal of makers to accept the terms offered, has prevented the closing of business. Business has not increased sufficiently at the bar mills to induce mill-owners to buy heavily, but there are some two or three in the market for moderate lots. Both buyers and sellers are confident that the market is pointing in the right direction. A great deal of inquiry has been made for Bessemer Pig, Spiegeleisen and Old Rails, and a good deal of business has been transacted. $30 is the asking price for 20 per cent. Spiegel, and $20 for Bessemer. Merchant Iron is moving slowly at 2c. in small lots. Nails are moderately active at $2.50. It is rumored that Steel Rails have been sold at less than $34, but the proof is lacking.

PITTSBURGH, Mar. 20, 1884.

No. 1 Foundry Iron is selling at $21 this week for best. No. 1 Mill Iron sold at $18 for best. Mill owners are not buying very heavily, but are covering current requirements, not with the hope of buying cheaper after a while, but because there is no reason for anticipating at present. There is a little more activity in finished Iron. Nails are moving in a jobbing way at $2.50@$2.60. A good deal of small railway material, such as spikes, nuts and bolts, has been called for. Small orders for Steel Rails are coming along. One structural mill has a large number of orders ahead. A good deal of material is going to the oil region.

CHICAGO, Mar. 20, 1884.

The indications are more favorable in the Iron Trade this week than last. There is an improved movement in season hardware. A good deal of material is going into the lumber camps, and large purchases have been made in railway supplies. Work has been begun on several short lines in the region contributory to this market. Refined Iron is more active. Nails are steady, sheet and galvanized is under better inquiry; builders' hardware will be wanted in large lots. Steel for agricultural implement purposes is in better demand. The outlook in the Northwest is considerably better, and, as soon as favorable weather arrives, business will be benefitted.

COAL.

The Eastern Pennsylvania Coal Trade is about taking a fresh start in consequence of the fixing of freight rates, which are satisfactory to all concerned. The Cumberland and Clearfield Coal interests have had their differences harmonized, and freight rates are now fixed so that competition has very little play. Orders have been placed for Clearfield Coal in New England markets, and a large amount of business that has been hanging fire for a long time will be placed next week. Anthracite is weaker, and there are rumors of a continuation of half-time after the 1st of April, but nothing definite is known. Manufacturers generally are ready to place heavy contracts, as Coal is selling lower now than for years, and there is talk of a combination amongst the Bituminous operators, which, if effected, will start prices upward.